EXHIBIT F
Part 3 of 3

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
10/806,775	03/22/2004	Lawrence G. Hopkins	CDM/8882.9999

CONFIRMATION NO. 2371

OC000000020632947
OC000000020632947

00152
CHERNOFF, VILHAUER, MCCLUNG & STENZEL
1600 ODS TOWER
601 SW SECOND AVENUE
PORTLAND, OR 97204-3157

Date Mailed: 09/28/2006

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 09/25/2006.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Dawn Brewer

DAWN BREWER
3700 (571) 272-4331

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APPLICATION NUMBER	FILING OR 371 (c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
10/806,775	03/22/2004	Lawrence G. Hopkins	HTR007-1P US

CONFIRMATION NO. 2371

OC000000020632885

OC000000020632885

34036
SILICON VALLEY PATENT GROUP LLP
2350 MISSION COLLEGE BOULEVARD
SUITE 360
SANTA CLARA, CA 95054

Date Mailed: 09/28/2006

NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 09/25/2006.

- The Power of Attorney to you in this application has been revoked by the assignee who has intervened as provided by 37 CFR 3.71. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Dawn Brewer

DAWN BREWER
3700 (571) 272-4331

OFFICE COPY

Notice of Allowability	Application No. 10/806,775	Applicant(s) HOPKINS, LAWRENCE G.	
	Examiner Ninh H. Nguyen	Art Unit 3745	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *the amendment dated 25 September 2006*.

2. ☒ The allowed claim(s) is/are *1-10,21,25,27,29,31-40 and 42-47*.

3. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____.
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

4. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)
1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____.
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

Ninh H. Nguyen
NINH H. NGUYEN
PRIMARY EXAMINER

UNITED STATES PATENT AND TRADEMARK OFFICE

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NOTICE OF ALLOWANCE AND FEE(S) DUE

00152 7590 10/12/2006

CHERNOFF, VILHAUER, MCCLUNG & STENZEL
1600 ODS TOWER
601 SW SECOND AVENUE
PORTLAND, OR 97204-3157

EXAMINER	
NGUYEN, NINH H	
ART UNIT	PAPER NUMBER
3745	

DATE MAILED: 10/12/2006

APPLICATION NO	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/806,775	03/22/2004	Lawrence G. Hopkins	CDM/8882.9999	2371

TITLE OF INVENTION: FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	$1400	01/12/2007

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

00152 7590 10/12/2006

CHERNOFF, VILHAUER, MCCLUNG & STENZEL
1600 ODS TOWER
601 SW SECOND AVENUE
PORTLAND, OR 97204-3157

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/806,775	03/22/2004	Lawrence G. Hopkins	CDM/8882.9999	2371

TITLE OF INVENTION: FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	$1400	01/12/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, NINH H	3745	415-119000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 ____________
2 ____________
3 ____________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☐ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies ____________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____________ Date ____________

Typed or printed name ____________ Registration No. ____________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/806,775	03/22/2004	Lawrence G. Hopkins	CDM/8882.9999	2371

00152 7590 10/12/2006

CHERNOFF, VILHAUER, MCCLUNG & STENZEL
1600 ODS TOWER
601 SW SECOND AVENUE
PORTLAND, OR 97204-3157

EXAMINER	
NGUYEN, NINH H	
ART UNIT	PAPER NUMBER
3745	

DATE MAILED: 10/12/2006

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 0 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 0 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 07/06) Approved for use through 04/30/2007.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P O Box 1450
Alexandria, Virginia 22313-1450
www uspto gov

APPLICATION NO	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO
10/806,775	11/21/2006	7137775	CDM/8882.9999	2371

152 7590 11/01/2006

CHERNOFF, VILHAUER, MCCLUNG & STENZEL
1600 ODS TOWER
601 SW SECOND AVENUE
PORTLAND, OR 97204-3157

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571) 272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at (703) 305-8283.

APPLICANT(s) (up to 18 names are included below, see PAIR WEB site http://pair.uspto.gov for additional applicants):

Lawrence G. Hopkins, Portland, OR;

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

00152 7590 10/12/2006

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1600 ODS TOWER
601 SW SECOND AVENUE
PORTLAND, OR 97204-3157

10/20/2006 EAREGAY2 00000010 10806775

01 FC:1501 1400.00 OP
02 FC:8001 9.00 OP

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

Charles D. McClung (Depositor's name)
[signature] (Signature)
October 16, 2006 (Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/806,775	03/22/2004	Lawrence G. Hopkins	CDM/8882.9999	2371

TITLE OF INVENTION: FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1400	$0	$1400	$1400	01/12/2007

EXAMINER	ART UNIT	CLASS-SUBCLASS
NGUYEN, NINH H	3745	415-119000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) the names of up to 3 registered patent attorneys or agents OR, alternatively,

(2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Chernoff, Vilhauer
2 McClung & Stenzel
3 LLP

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: Huntair Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Tualatin, Oregon

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☒ Advance Order - # of Copies 3

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☒ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number 03-1550 (enclose an extra copy of this form).

5. Change in Entity Status (from status indicated above)
☐ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
☐ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature [signature] Date October 16, 2006

Typed or printed name Charles D. McClung Registration No. 26,568

OIPE IAP55 OCT 19 2006 PATENT & TRADEMARK OFFICE

CVMS

LAW OFFICES
CHERNOFF, VILHAUER, MCCLUNG & STENZEL, LLP
INTELLECTUAL PROPERTY LAW
INCLUDING PATENT, TRADEMARK, COPYRIGHT
AND UNFAIR COMPETITION MATTERS

1600 ODS TOWER
601 S.W. SECOND AVENUE
PORTLAND, OREGON 97204-3157
TELEPHONE: 503-227-5631
FAX: 503-228-4373

* JACOB E. VILHAUER, JR.
* DENNIS E. STENZEL
* CHARLES D. MCCLUNG
* DONALD B. HASLETT
* J. PETER STAPLES
* WILLIAM O. GENY
* NANCY J. MORIARTY
* KEVIN L. RUSSELL

DANIEL P. CHERNOFF
(1935-1995)

* TIM A. LONG
KURT ROHLFS
BRENNA K. LEGAARD
SUSAN D. PITCHFORD
J. DOUGLAS WELLS
HOLLY L. BONAR

* REGISTERED PATENT ATTORNEY

DAVID S. FINE
SENIOR LAW CLERK

October 16, 2006

Our File: 8887.0006

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Re: U.S. Patent Application Serial No. 10/806,775 of Huntair Inc. Entitled <u>FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS</u>

Dear Sir or Madam:

Enclosed is Form PTOL-85B (Issue Fee Transmittal), in duplicate, with regard to the above-identified patent application, along with a check in the amount of $1,409 for payment of the Issue Fee ($1,400) and three advance copies of the patent ($9).

Please address all notices regarding the payment of maintenance fees on the above-identified patent to Chernoff, Vilhauer, McClung & Stenzel, LLP, at the then current address for payor number 00152.

The Commissioner is hereby authorized to charge payment of the foregoing fee, or credit any overpayment, to Deposit Account No. 03-1550. A duplicate copy of this letter is enclosed.

Respectfully submitted,

Charles D. McClung
Reg. No. 26,568
Attorney for Applicant

CDM/lma
Enclosures

L Number	Hits	Search Text	DB	Time stamp
7	7514	fan same array	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/09/09 15:44
8	1078	(fan same array) and cool	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/09/09 15:44
9	142	((fan same array) and cool) and (fan same controller)	USPAT; US-PGPUB; EPO; JPO; DERWENT	2004/09/09 15:53

EAST Search History

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	0	(fan and array and plurality and compartment and efficiency and operat$3 and controller and peak and strategic$3).clm.	US-PGPUB	OR	ON	2006/10/06 09:06

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	4	(fan and array and plurality and compartment and efficiency and operat$3 and controller and peak and strategic$3)	US-PGPUB	OR	ON	2006/01/23 14:01

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L8	755	(fan same array)and control and efficiency and program	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2005/12/01 08:24
L9	49	8 and (air same handl$3)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2005/12/01 08:25
L10	0	9 and (on same off)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2005/12/01 08:26
L11	29	9 and (compartment or chamber)	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2005/12/01 08:26

ARTIFACT SHEET

Enter artifact number below. Artifact number is application number + artifact type code (see list below) + sequential letter (A. B. C ...). The first artifact folder for an artifact type receives the letter A. the second B. etc.. Examples: 59123456PA, 59123456PB, 59123456ZA, 59123456ZB

10806775 ZA

Indicate quantity of a single type of artifact received but not scanned. Create individual artifact folder/box and artifact number for each Artifact Type.

- [ ] CD(s) containing:
  - computer program listing [ ]
    Doc Code: Computer — Artifact Type Code: P
  - pages of specification and/or sequence listing and/or table [ ]
    Doc Code: Artifact — Artifact Type Code: S
  - content unspecified or combined [ ]
    Doc Code: Artifact — Artifact Type Code: U
- [ ] Stapled Set(s) Color Documents or B/W Photographs
  Doc Code: Artifact — Artifact Type Code: C
- [ ] Microfilm(s)
  Doc Code: Artifact — Artifact Type Code: F
- [ ] Video tape(s)
  Doc Code: Artifact — Artifact Type Code: V
- [ ] Model(s)
  Doc Code: Artifact — Artifact Type Code: M
- [ ] Bound Document(s)
  Doc Code: Artifact — Artifact Type Code: B
- [ ] Confidential Information Disclosure Statement or Other Documents marked Proprietary, Trade Secrets, Subject to Protective Order, Material Submitted under MPEP 724.02, etc.
  Doc Code: Artifact — Artifact Type Code X
- [1] Other, description: AF/D (Appendix A)
  Doc Code: Artifact — Artifact Type Code: Z

March 8, 2004

ARTIFACT SHEET

Enter artifact number below. Artifact number is application number + artifact type code (see list below) + sequential letter (A, B, C ...). The first artifact folder for an artifact type receives the letter A, the second B, etc.. Examples: 59123456PA, 59123456PB, 59123456ZA, 59123456ZB

10806779 BA

Indicate quantity of a single type of artifact received but not scanned. Create individual artifact folder/box and artifact number for each Artifact Type.

☐ CD(s) containing:
- computer program listing ☐
  Doc Code: Computer — Artifact Type Code: P
- pages of specification and/or sequence listing and/or table ☐
  Doc Code: Artifact — Artifact Type Code: S
- content unspecified or combined ☐
  Doc Code: Artifact — Artifact Type Code: U

☐ Stapled Set(s) Color Documents or B/W Photographs
Doc Code: Artifact — Artifact Type Code: C

☐ Microfilm(s)
Doc Code: Artifact — Artifact Type Code: F

☐ Video tape(s)
Doc Code: Artifact — Artifact Type Code: V

☐ Model(s)
Doc Code: Artifact — Artifact Type Code: M

☑ Bound Document(s)
Doc Code: Artifact — Artifact Type Code: B

☐ Confidential Information Disclosure Statement or Other Documents marked Proprietary, Trade Secrets, Subject to Protective Order, Material Submitted under MPEP 724.02, etc.
Doc Code: Artifact — Artifact Type Code X

☐ Other, description: ______________________
Doc Code: Artifact — Artifact Type Code: Z

March 8, 2004

PATENT APPLICATION FEE DETERMINATION RECORD
Effective October 1, 2003

Application or Docket Number: 10806775

CLAIMS AS FILED - PART I

	(Column 1)	(Column 2)
TOTAL CLAIMS	20	
FOR	NUMBER FILED	NUMBER EXTRA
TOTAL CHARGEABLE CLAIMS	20 minus 20=	*
INDEPENDENT CLAIMS	2 minus 3 =	*
MULTIPLE DEPENDENT CLAIM PRESENT		☐

SMALL ENTITY TYPE ☐ OR OTHER THAN SMALL ENTITY

RATE	FEE		RATE	FEE
BASIC FEE	385.00	OR	BASIC FEE	770.00
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL	385	OR	TOTAL	

* If the difference in column 1 is less than zero, enter "0" in column 2

CLAIMS AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 31	Minus	** 20	= 11
Independent	* 2	Minus	*** 3	= —
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

SMALL ENTITY OR OTHER THAN SMALL ENTITY

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9= (25)	275	OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE	270	OR	TOTAL ADDIT. FEE	

11/22/05

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	* 31	Minus	** 31	= —
Independent	* 2	Minus	*** 3	= —
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

AMENDMENT C

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA
Total	*	Minus	**	=
Independent	*	Minus	***	=
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM				☐

RATE	ADDITIONAL FEE		RATE	ADDITIONAL FEE
X$ 9=		OR	X$18=	
X43=		OR	X86=	
+145=		OR	+290=	
TOTAL ADDIT. FEE		OR	TOTAL ADDIT. FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

FORM PTO-875 (Rev. 10/03) Patent and Trademark Office, U.S. DEPARTMENT OF COMMERCE

MPI Family Report (Family Bibliographic and Legal Status)

In the MPI Family report, all publication stages are collapsed into a single record, based on identical application data. The bibliographic information displayed in the collapsed record is taken from the latest publication.

Report Created Date: 2007-12-13

Name of Report:

Number of Families: 1

Comments:

Table of Contents

Family1

16 records in the family, collapsed to 12 records.

CA2516215A1 20041007

[no drawing available]

(ENG) FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS

Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE G US

Application No: CA 2516215 A

Filing Date: 20040319

Issue/Publication Date: 20041007

Priority Data: US 45641303 20030320 P; US 2004008578 20040319 W W;

IPC (International Class): F04D02700

ECLA (European Class): F04D02516C; F24F00706

Publication Language: ENG

Legal Status:

Date	+/-	Code	Description
20050812		AFNE	NATIONAL PHASE ENTRY
20050812		EEER	EXAMINATION REQUEST

CN1795334A 20060628

(ENG) Fan array fan section in air-handling systems

Assignee: HUNTAIR INC US

[no drawing available]

Inventor(s): HOPKINS LAWRENCE G US

Application No: CN 200480006686 A

Filing Date: 20040319

Issue/Publication Date: 20060628

Abstract: NotAvailable

Priority Data: US 45641303 20030320 P;

IPC (International Class): F04D02700; F24F00706; F04D02516

ECLA (European Class): F04D02516C; F24F00706

Legal Status: There is no Legal Status information available for this patent

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EP1604116A4 20070523
EP1604116A2 20051214

(ENG) FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS

[no drawing available]

Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE G US

Application No: EP 04757940 A

Filing Date: 20040319

Issue/Publication Date: 20070523

Abstract: NotAvailable

Priority Data: US 45641303 20030320 P; US 2004008578 20040319 W W;

IPC (International Class): F04D02700; F04D02516; F24F00706

ECLA (European Class): F04D02516; F24F00706

Designated Countries:
----Designated States: AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PL PT RO SE SI SK TR

Publication Language: ENG

Filing Language: ENG

Legal Status:

Date	+/-	Code	Description
20070523	( )	A4	SUPPLEMENTARY SEARCH REPORT Effective date: 20070419;
20070523	( )	RIC1	CLASSIFICATION (CORRECTION) IPC: F04D 27/00 20060101AFI20050425BHEP;
20070523	( )	RIC1	CLASSIFICATION (CORRECTION) IPC: F04D 25/16 20060101ALI20070413BHEP;

JP2006519972T 20060831

NotAvailable

Application No: JP 2005518910 T

[no drawing available]

Filing Date: 20040319

Issue/Publication Date: 20060831

Abstract: NotAvailable

Priority Data: US 45641303 20030320 P; US 2004008578 20040319 W W;

IPC (International Class): F24F00100; F24F01104; F24F00706; F04D02516

ECLA (European Class): F04D02516C; F24F00706

Legal Status: There is no Legal Status information available for this patent

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KR20050115898A 20051208

(ENG) FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEM

Assignee: HUNTAIR INC US

[no drawing available]

Inventor(s): HOPKINS LAWRENCE G US

Application No: KR 20057016754 A

Filing Date: 20050908

Issue/Publication Date: 20051208

Abstract: NotAvailable

Priority Data: US 45641303 20030320 P;

ECLA (European Class): F04D02516C; F24F00706

Legal Status: There is no Legal Status information available for this patent

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MXPA05009943A 20051104

(ENG) FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS.

[no drawing available]

Assignee: HUNTAIR INC US

Inventor(s): LAWRENCE G HOPKINS US

Application No: MX PA05009943 A

Filing Date: 20050919

Issue/Publication Date: 20051104

Abstract: (SPA) Una seccion de ventiladores del conjunto de ventiladores en un sistema de distribucion de aire, que comprende una pluralidad de unidades de ventilacion (200) dispuestas en un conjunto de ventilacion y colocadas dentro de una seccion de distribucion de aire (202). Una modalidad preferida puede incluir un Controlador de conjunto (300) programado para hacer funcionar la pluralidad de unidades de ventilacion (200) a substancialmente su maxima eficiencia. La pluralidad de unidades de ventilacion (200) puede quedar dispuesta en una configuracion de conjunto exacta o pareja, en una configuracion de conjunto de modelo espaciada, en una configuracion de conjunto en forma de tablero de ajedrez, en una configuracion de conjunto de hileras ligeramente descentradas, en una configuracion de conjunto de columnas ligeramente descentradas; y en una configuracion de conjunto, escalonada. A fan array fan section in an air-handling system comprising includes a plurality of fan units (200) arranged in a fan array and positioned within an air-handling compartment (202). One preferred embodiment may include an array controller (300) programmed to operate the plurality of fan units (200) at substantially peak efficiency. The plurality of fan units (200) may be arranged in a true array configuration, a spaced pattern array configuration, a checker board array configuration, rows slightly offset array configuration, columns slightly offset array configuration, or a staggered array configuration.

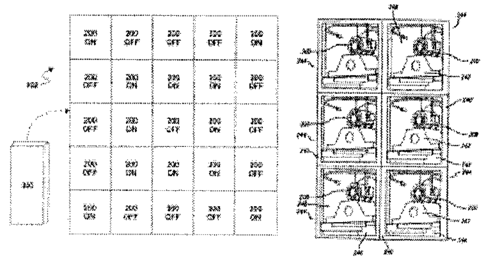
Priority Data: US 45641303 20030320 P; US 2004008578 20040319 W W;

IPC (International Class): F24F00706; F04D02516

ECLA (European Class): F04D02516C; F24F00706

Publication Language: SPA

Legal Status: There is no Legal Status information available for this patent



US7179046B2 20070220
US2005232753A1 20051020

(ENG) Fan array fan section in air-handling systems

Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE G US

Application No: US 15489405 A

Filing Date: 20050615

Issue/Publication Date: 20070220

Abstract: (ENG) A fan array fan section in an air-handling system includes a plurality of fan units arranged in a fan array and positioned within an air-handling compartment. One preferred embodiment may include an array controller programmed to operate the plurality of fan units at peak efficiency. The plurality of fan units may be arranged in a true array configuration, a spaced pattern array configuration, a checker board array configuration, rows slightly offset array configuration, columns slightly offset array configuration, or a staggered array configuration.

Priority Data: US 15489405 20050615 A; US 45641303 20030320 P; US 55470204 20040320 P; US 80677504 20040322 A 1; US 2004008578 20040319 W W;

Related Application(s): 11/154894 20050615 20050232753 20051020 US; 60/554702 20040320 US; 60/456413 20030320 US; 10/806775 20040322 7137775 US; PCT/US2004008578 20040319 US PENDING

IPC (International Class): F04D02516; F24F00706

ECLA (European Class): F04D02516; F24F00706

US Class: 415061; 415119; 416120; 417003; 4174235; 417426

Publication Language: ENG

Filing Language: ENG

Agent(s): Chernoff, Vilhauer, McClung & Stenzel, LLP

Examiner Primary: Nguyen, Ninh H.

Assignments Reported to USPTO:

Reel/Frame: 16702/0901 **Date Signed:** 20040322 **Date Recorded:** 20050615
Assignee: HUNTAIR INC. 11555 SW MYSLONY STREET TUALATIN OREGON 97062

Assignor: HOPKINS, LAWRENCE G.

Corres. Addr: KAREN DANA OSTER LAW OFFICE OF KAREN DANA OSTER, LLC PMB 1020, 15450 SW BOONES FERRY RD. #9 LAKE OSWEGO, OREGON 97035
Brief: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Reel/Frame: 17586/0137 **Date Signed:** 20060427 **Date Recorded:** 20060508
Assignee: UBS AG, STAMFORD BRANCH, AS ADMINISTRATIVE AGENT 677 WASHINGTON BOULEVARD STAMFORD CONNECTICUT 06901

Assignor: CLEANPAK INTERNATIONAL, INC.; HUNTAIR, INC.

Corres. Addr: CORPORATION SERVICE COMPANY 1133 AVENUE OF THE AMERICAS SUITE 3100 NEW YORK, NY 10036
Brief: SECURITY AGREEMENT

Reel/Frame: 18221/0001 **Date Signed:** 20060414 **Date Recorded:** 20060724
Assignee: HUNTAIR, INC. (A DELAWARE CORPORATION) 11555 SW MYSLONY STREET (FORMERLY KNOWN AS ACQUISITION SUB 2006-2, INC.) TUALATIN OREGON 97062

Assignor: HUNTAIR INC. (AN OREGON CORPORATION)

Corres. Addr: DAWN URBANOWICZ C/O NORTEK, INC. 50 KENNEDY PLAZA PROVIDENCE, RI 02903
Brief: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Legal Status: There is no Legal Status information available for this patent

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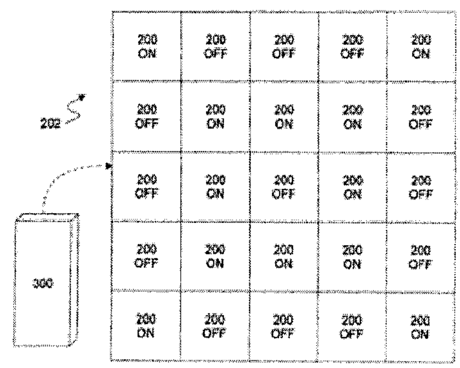
WO2004085928A3 20050421
WO2004085928A2 20041007

(ENG) FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS



Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE G US

Application No: US 2004008578 W

Filing Date: 20040319

Issue/Publication Date: 20050421

Abstract: L'invention concerne un ensemble soufflante à série de soufflantes pour systèmes de traitement d'air, qui comprend une pluralité d'unités de soufflante (200) disposées en série et placées dans un compartiment de traitement d'air (202). En mode de réalisation préféré, il peut exister un contrôleur de série (300) programmé pour exploiter la pluralité d'unités (200) sensiblement à l'efficacité de crête. Cette pluralité d'unités (200) peut être disposée en configuration de série réelle, en configuration de série à structure espacée, en configuration de série à damier, en configuration de série à rangées légèrement décalées, en configuration de série à colonnes légèrement décalées, ou en configuration de série à échelonnement.

Priority Data: US 45641303 20030320 P;

IPC (International Class): F24F00706; F04D02516

ECLA (European Class): F04D02516; F24F00706

Designated Countries:
----Designated States: AE AE AG AL AL AM AM AM AT AT AU AZ AZ BA BB BG BG BR BR BW BY BY BZ BZ CA CH CN CN CO CO CR CR CU CU CZ CZ DE DE DK DK DM DZ EC EC EE EE EG EG ES ES FI FI GB GD GE GE GH GM HR HR HU HU ID IL IN IS JP JP KE KE KG KG KP KP KP KR KR KZ KZ KZ LC LK LR LS LS LT LU LV MA MD MD MG MK MN MW MX MX MZ MZ NA NI NI NO NZ OM PG PH PH PL PL PT PT RO RU RU SC SD SE SG SK SK SL SL SY TJ TJ TM TM TN TR TR TT TT TZ UA UA UG UG US UZ UZ VC VN YU YU ZA ZM ZW
----Regional Treaties: AM AT AZ BE BF BF BG BJ BJ BW BY CF CF CG CG CH CI CI CM CM CY CZ DE DK EE ES FI FR GA GA GB GH GM GN GN GQ GQ GR GW GW HU IE IT KE KG KZ LS LU MC MD ML ML MR MR MW MZ NE NE NL PL PT RO RU SD SE SI SK SL SN SN SZ TD TD TG TG TJ TM TR TZ UG ZM ZW

Publication Language: ENG

Agent(s): OSTER, Karen, Dana Law Office of Karen Dana Oster, LLC, PMB 1020, 15450 SW Boones Ferry Rd#9, Lake Oswego, OR 97035, US US

Legal Status: There is no Legal Status information available for this patent

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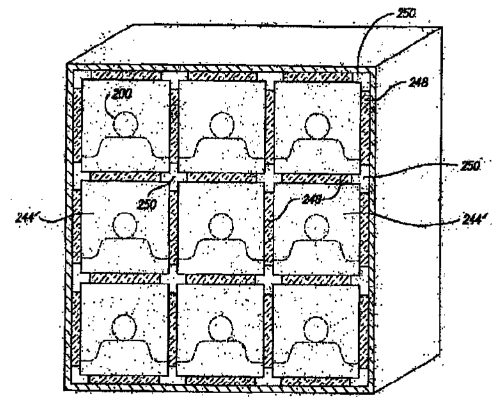

WO2006104735A1 20061005

(ENG) FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS

Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE US

Application No: US 2006009842 W

Filing Date: 20060316

Issue/Publication Date: 20061005

Abstract: (ENG) <emi file="US2006009842_05102006_pf_fp.g4" he="151MM" wi="184MM"/><p>A fan array fan section in an air-handling system includes a plurality of fan units arranged in a fan array. Each fan unit is positioned within a fan unit chamber/cell. Each fan unit chamber/cell has at least one acoustically absorptive insulation surface. The insulation surfaces of the fan unit chambers/cells together form a coplanar silencer. Sound waves from the fan units passing through the insulation surface at least partially dissipate as they pass therethrough. In one preferred embodiments the fan unit chamber/cell is a cell having a frame that supports the insulation surfaces.</p>

Priority Data: US 9756105 20050331 A;

IPC (International Class): F24F01100; H05K00720

ECLA (European Class): F24F003044; F24F007007

Designated Countries:

----Designated States: AE AG AL AM AT AU AZ BA BB BG BR BW BY BZ CA CH CN CO CR CU CZ DE DK DM DZ EC EE EG ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KM KN KP KR KZ LC LK LR LS LT LU LV LY MA MD MG MK MN MW MX MZ NA NG NI NO NZ OM PG PH PL PT RO RU SC SD SE SG SK SL SM SY TJ TM TN TR TT TZ UA UG US UZ VC VN YU ZA ZM ZW

----Regional Treaties: AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LT LU LV MC NL PL PT RO SE SI SK TR BF BJ CF CG CI CM GA GN GQ GW ML MR NE SN TD TG BW GH GM KE LS MW MZ NA SD SL SZ TZ UG ZM ZW AM AZ BY KG KZ MD RU TJ TM

Publication Language: ENG

Agent(s): STEUBER, David SILICON VALLEY PATENT GROUP LLP, 2350 Mission College Blvd., Suite 360, Santa Clara, California 95054 US

Legal Status: There is no Legal Status information available for this patent

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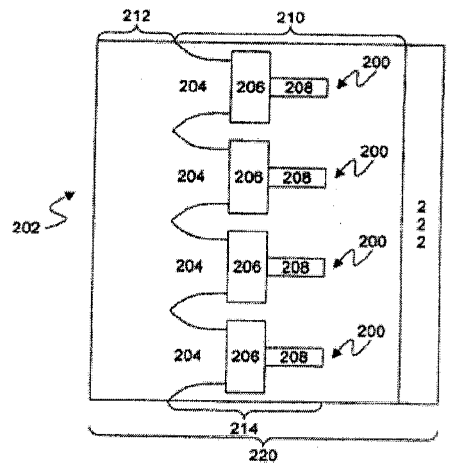


US2007104568A1 20070510

(ENG) Fan array fan section in air-handling systems

Inventor(s): HOPKINS LAWRENCE G US

Application No: US 59521206 A

Filing Date: 20061109

Issue/Publication Date: 20070510

Abstract: (ENG) A fan array fan section in an air-handling system includes a plurality of fan units arranged in a fan array and positioned within an air-handling compartment. One preferred embodiment may include an array controller programmed to operate the plurality of fan units at peak efficiency. The plurality of fan units may be arranged in a true array configuration, a spaced pattern array configuration, a checker board array configuration, rows slightly offset array configuration, columns slightly offset array configuration, or a staggered array configuration.

Priority Data: US 45641303 20030320 P; US 55470204 20040320 P; US 59521206 20061109 A; US 80677504 20040322 A 1; US 2004008578 20040319 W W;

Related Application(s): 60/456413 20030320 US; 60/554702 20040320 US; 10/806775 20040322 7137775 US GRANTED; PCT/US2004008578 20040319 US PENDING

IPC (International Class): F04D02966; F04D02516; F24F00706

ECLA (European Class): F04D02516C; F24F00706

US Class: 415119

Publication Language: ENG

Filing Language: ENG

Assignments Reported to USPTO:

Reel/Frame: 18710/0071 **Date Signed:** 20061213 **Date Recorded:** 20061222

Assignee: HUNTAIR, INC. 11555 S.W. MYSLONY STREET TUALATIN OREGON 97062

Assignor: HOPKINS, LAWRENCE G.

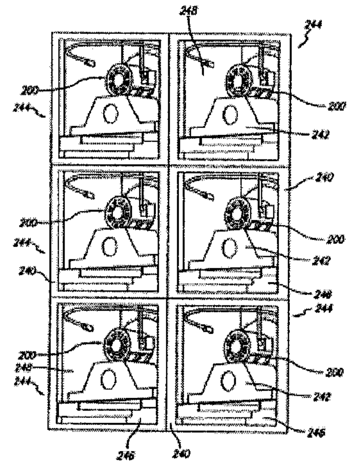
Corres. Addr: CHARLES D. MCCLUNG CHERNOFF, VILHAUER, MCCLUNG & ET AL. 1600 ODS TOWER 601 S.W. SECOND AVENUE PORTLAND, OR 97204-3157

Brief: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Legal Status:

Date	+/-	Code	Description
20061222	( )	AS	ASSIGNMENT New owner name: HUNTAIR, INC., OREGON; : ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:HOPKINS, LAWRENCE G.;REEL/FRAME:018710/0071; Effective date: 20061213;

US7137775B2 20061121
US2004185771A1 20040923



(ENG) Fan array fan section in air-handling systems

Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE G US

Application No: US 80677504 A

Filing Date: 20040322

Issue/Publication Date: 20061121

Abstract: (ENG) <p num="0000">A fan array fan section in an air-handling system includes a plurality of fan units arranged in a fan array and positioned within an air-handling compartment. One preferred embodiment may include an array controller programmed to operate the plurality of fan units at peak efficiency. The plurality of fan units may be arranged in a true array configuration, a spaced pattern array configuration, a checker board array configuration, rows slightly offset array configuration, columns slightly offset array configuration, or a staggered array configuration. </p>

Priority Data: US 45641303 20030320 P; US 55470204 20040320 P; US 80677504 20040322 A; US 2004008578 20040319 W W;

Related Application(s): 60/554702 20040320 00 60/456413 20030320 00; 10/806775 PCT/US04/08578 20040319 PENDING

IPC (International Class): F04D02516; F24F00706

ECLA (European Class): F04D02516C; F24F00706

US Class: 415061; 415119; 416120; 417003; 4174235; 417426

Publication Language: ENG

Agent(s): Silicon Valley Patent Group LLP

Examiner Primary: Nguyen, Ninh H.

Assignments Reported to USPTO:

Reel/Frame: 15136/0541 **Date Signed:** 20040322 **Date Recorded:** 20040322
Assignee: HUNTAIR INC. 11555 SW MYSLONY STREET TUALATIN OREGON 97062

Assignor: HOPKINS, LAWRENCE G.

Corres. Addr: LAW OFFICE OF KAREN DANA OSTER, LLC KAREN DANA OSTER 15450 SW BOONES FERRY RD. #9 PMB 1020 LAKE OSWEGO, OR 97035
Brief: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Reel/Frame: 17586/0137 **Date Signed:** 20060427 **Date Recorded:** 20060508
Assignee: UBS AG, STAMFORD BRANCH, AS ADMINISTRATIVE AGENT 677 WASHINGTON BOULEVARD STAMFORD CONNECTICUT 06901

Assignor: CLEANPAK INTERNATIONAL, INC. ; HUNTAIR, INC.

Corres. Addr: CORPORATION SERVICE COMPANY 1133 AVENUE OF THE AMERICAS SUITE 3100 NEW YORK, NY 10036

Brief: SECURITY AGREEMENT

Reel/Frame: 18221/0001 **Date Signed:** 20060414 **Date Recorded:** 20060724
Assignee: HUNTAIR, INC. (A DELAWARE CORPORATION) 11555 SW MYSLONY STREET (FORMERLY KNOWN AS ACQUISITION SUB 2006-2, INC.) TUALATIN OREGON 97062

Assignor: HUNTAIR INC. (AN OREGON CORPORATION)

Corres. Addr: DAWN URBANOWICZ C/O NORTEK, INC. 50 KENNEDY PLAZA PROVIDENCE, RI 02903
Brief: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Legal Status:

Date	+/-	Code	Description
20060724		AS	ASSIGNMENT New owner name: HUNTAIR, INC. (A DELAWARE CORPORATION), OREGON; : ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:HUNTAIR INC. (AN OREGON CORPORATION);REEL/FRAME:018221/0001; Effective date: 20060414;

US2005180846A1 20050818

(ENG) Fan array fan section in air-handling systems

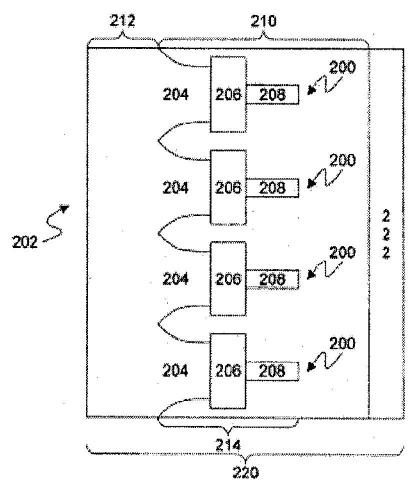
Assignee: HUNTAIR INC US

Inventor(s): HOPKINS LAWRENCE G US

Application No: US 9756105 A

Filing Date: 20050331

Issue/Publication Date: 20050818



Abstract: (ENG) <p num="0000">A fan array fan section in an air-handling system includes a plurality of fan units arranged in a fan array. Each fan unit is positioned within a fan unit chamber/cell. Each fan unit chamber/cell has at least one acoustically absorptive insulation surface. The insulation surfaces of the fan unit chambers/cells together form a coplanar silencer. Sound waves from the fan units passing through the insulation surface at least partially dissipate as they pass therethrough. In one preferred embodiments the fan unit chamber/cell is a cell having a frame that supports the insulation surfaces. </p>

Priority Data: US 9756105 20050331 A Z; US 45641303 20030320 P; US 55470204 20040320 P; US 80677504 20040322 A 2; US 2004008578 20040319 W W;

Related Application(s): 60/456413 20030320 60/554702 20040320; 11/097561 20050331 10/806775 20040322 PENDING 11/097561 20050331 PCT/US04/08578 20040319 PENDING

IPC (International Class): F25D02312; F04D02966; F03B01104; F03D01100; F01D00516; F01D00526; F01D00510; F01D02504; F25D01500

ECLA (European Class): F04D02516C; F24F00706

US Class: 415119

Publication Language: ENG

Assignments Reported to USPTO:

Reel/Frame: 17586/0137 **Date Signed:** 20060427 **Date Recorded:** 20060508
Assignee: UBS AG, STAMFORD BRANCH, AS ADMINISTRATIVE AGENT 677 WASHINGTON BOULEVARD STAMFORD CONNECTICUT 06901

Assignor: CLEANPAK INTERNATIONAL, INC. ; HUNTAIR, INC.

Corres. Addr: CORPORATION SERVICE COMPANY 1133 AVENUE OF THE AMERICAS SUITE 3100 NEW YORK, NY 10036
Brief: SECURITY AGREEMENT

Reel/Frame: 18221/0001 **Date Signed:** 20060414 **Date Recorded:** 20060724
Assignee: HUNTAIR, INC. (A DELAWARE CORPORATION) 11555 SW MYSLONY STREET (FORMERLY KNOWN AS ACQUISITION SUB 2006-2, INC.) TUALATIN OREGON 97062

Assignor: HUNTAIR INC. (AN OREGON CORPORATION)

Corres. Addr: DAWN URBANOWICZ C/O NORTEK, INC. 50 KENNEDY PLAZA PROVIDENCE, RI 02903
Brief: ASSIGNMENT OF ASSIGNORS INTEREST (SEE DOCUMENT FOR DETAILS).

Legal Status:

Date	**+/-**	**Code**	**Description**
20060508		AS	ASSIGNMENT New owner name: UBS AG, STAMFORD BRANCH, AS ADMINISTRATIVE AGENT,; : SECURITY AGREEMENT;ASSIGNORS:CLEANPAK INTERNATIONAL, INC.;HUNTAIR, INC.;REEL/FRAME:017586/0137;SIGNING DATES FROM 20060426 TO 20060427;
20060724		AS	ASSIGNMENT New owner name: HUNTAIR, INC. (A DELAWARE CORPORATION), OREGON; : ASSIGNMENT OF ASSIGNORS INTEREST;ASSIGNOR:HUNTAIR INC. (AN OREGON CORPORATION);REEL/FRAME:018221/0001; Effective date: 20060414;

USPTO Maintenance Report					
Patent Bibliographic Data			12/13/2007 05:24 PM		
Patent Number:	7137775		Application Number:	10806775	
Issue Date:	11/21/2006		Filing Date:	03/22/2004	
Title:	FAN ARRAY FAN SECTION IN AIR-HANDLING SYSTEMS				
Status:	4th year fee window opens: 11/23/2009			Entity:	Large
Window Opens:	11/23/2009	Surcharge Date:	05/24/2010	Expiration:	N/A
Fee Amt Due:	Window not open	Surchg Amt Due:	Window not open	Total Amt Due:	Window not open
Fee Code:	1551	MAINTENANCE FEE DUE AT 3.5 YEARS			
Surcharge Fee Code:					
Most recent events (up to 7):		No Maintenance History Found --- End of Maintenance History ---			
Address for fee purposes:	CHERNOFF, VILHAUER, MCCLUNG & STENZEL 1600 ODS TOWER 601 SW SECOND AVENUE PORTLAND, OR 972043157				

AAON, Inc.

1421 South Yukon Ave., Tulsa, Oklahoma 74107-8723 · Ph. (918) 583-2266 Fax (918) 583-6094

Best Available Copy

Worksheet

.RL-075-3-0-AA04-000:A000-E00-JAZ-A0A-GA0ADBJ-00-00000000X

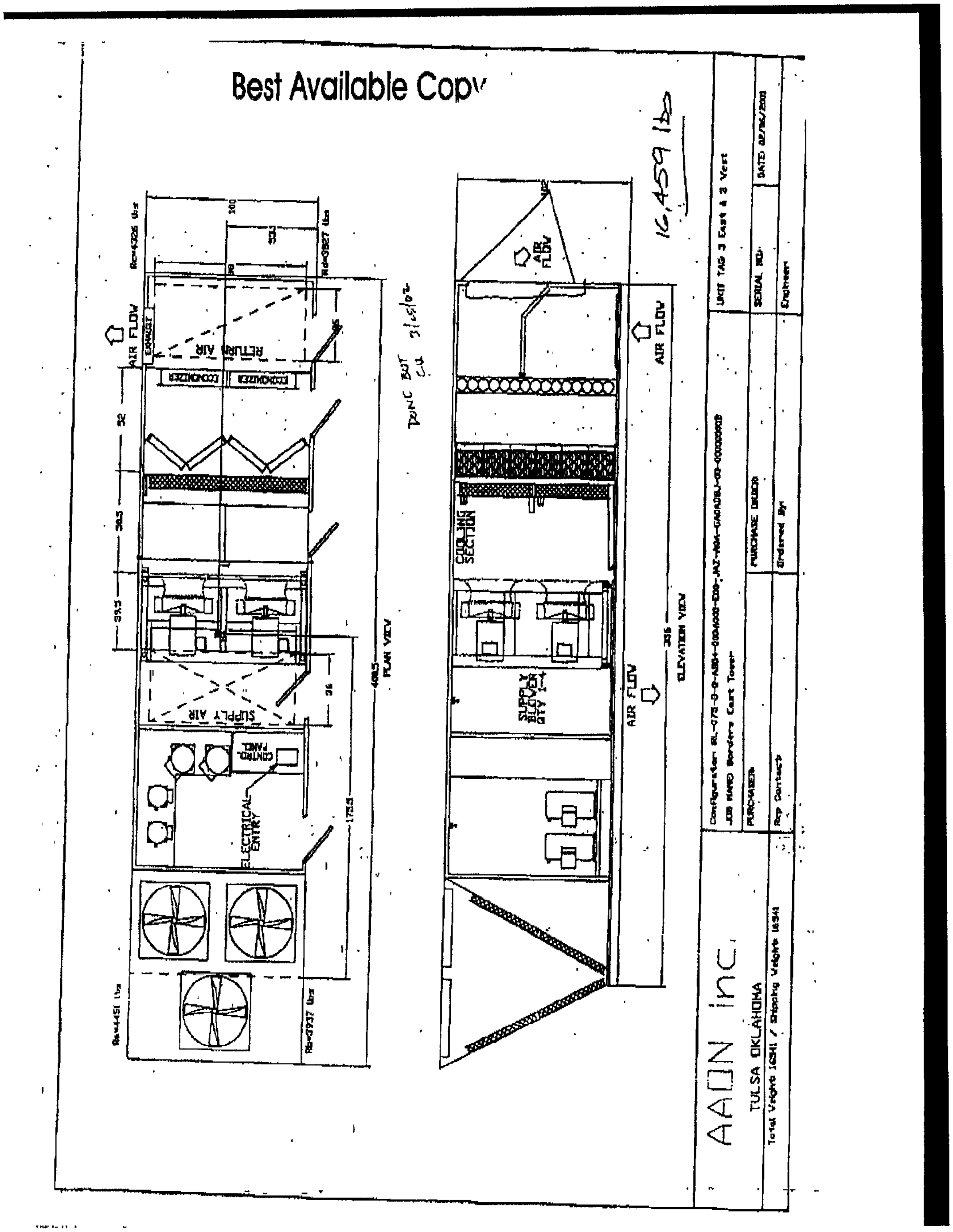
Tag: 3 West

Job Name:	Borders Best Tower	Worksheet For:	Borders Group Inc.
Job Number:	Job #7	Worksheet Date:	February 26, 2001

	Base Option	Description	List Price	Rep. Price	Cust. Price
R	Series	Roof Top Unit			
L	Generation	Eighth Generation			
075	Size	Seventy Five			
3	Voltage	460V/3Ø/60Hz	[redacted]	[redacted]	[redacted]
0	Interior Protection	Standard			
A	Cooling Style	Draw Thru - R22 Dual Circuited Compressors			
A	Cooling Configuration	Air Cooled Cond w/ 4R Coil High CFM			
0	Cooling Coating	Std			
4	Cooling Stages	4 Stage			
0	Heating Type	No Heat			
0	Heating Designation	No Heat			
0	Heating Stages	No Heat			

	Feature Option	Description	List Price	Rep. Price	Cust. Price
A	1A.Outside Air Options	Economizer	[redacted]	[redacted]	[redacted]
0	1B.RA Blower Configuration	Std (No return or exhaust blower)			
0	1C.RA Blower	Std (No return or exhaust blower)			
0	1D.RA Motor	Std (No Motor)			
E	2.Outside Air Controls	DDC Econ Control			
0	3.Discharge Location	Bottom Discharge			
0	4.Return Location	Bottom Return			
J	5A.SA Blower Configuration	2 Blowers w/Prem eff mtr1 w/1-VFD			
A	5B.SA Blower	Blower A (27" Diameter)			
Z	5C.SA Motor	20.0 hp (1760 rpm)			
A	6A.Pre Filter	4" Pleated			
0	6B.Final Filter	Std			
A	6C.Filter Options	CFS Pre Filter			
G	7.Refrigeration Controls	5 MTDR On & Off + 115V Outlet Factory Wired			
A	8.Refrigeration Options	Hot Gas Bypass Lead Stage (HGB)			
0	9.Refrigeration Accessories	Std			
A	10.Power Options	225 Amps Power Switch			
D	11.Safety options	R/A & S/A Smoke Detector			
B	12.Controls	Phase & Brown Out Protection			
J	13.Special Controls	Factory Installed DDC Controls by Others			
0	14A.Pre-Heat Configuration	Std (No Preheat)			
0	14B.Pre-Heat Sizing	Std (No Preheat)			
0	15.Option Boxes	Std			
0	16 Cabinet Options	Std			
0	17.Cabinet Options	Std			
0	18.Customer Code	Std			
0	19.Code Options	Std ETL USA Listing			
0	20.Unit Splits	Std (One Piece Unit)			
0	21.Evap & Water Condenser	Std (No Evap or Water Condenser)			
0	22.Blank	Std			
X	23.Type	Special Price Authorization & Cray Paint			
		Subtotal			
		Quantity			
		Total			

Best Available Copy



AAON, Inc.
2425 S. Yukon • Tulsa, OK 74107 • Ph:(918) 583-2266 • Fax:(918) 583-6094

DATE: 9/15/98 PAGE ___ of ___ **Order Form**

SOLD TO:
BOVIS CONSTRUCTION CORP
PRINCETON FORRESTAL VILLAGE
100-200 VILLAGE BLVD.
PRINCETON, N.J. 08540

CUSTOMER P.O. No. ___ JOB No. ___
JOB NAME: THE COMMONS
[redacted] AAON CONTACT: J. BARBERA
CUSTOMER ORDER No. 19[redacted] CUST. CONTACT: K. GABRIEL
REP. #1 757 REP. #2 ___

SHIP TO:
(WILL ADVISE)

SHIPPING INFORMATION
REQ. SHIP DATE: ___ HOLD FOR APPROVAL ☐ RELEASE TO PRODUCTION ☐
SHIP VIA: FRT ALLOWED
ALLOWED ☐ PPD & ADD ACTUAL ☐ COLLECT ☐
NOTIFY: RICK
48 HOURS BEFORE DELIVERY @ PHONE No.: 609/419-1380

MARKETING CODE: 50 SHIP ZONE:

QTY	PART NO.	DESCRIPTION	UNIT NET	EXT.
6		RF110-3-F0-1DL : N L L J Ø D G Ø J Ø 1 Ø Ø A X	[redacted]	
		CFM ESP NOTE! (1) TAG# 1A 2A 3A 4A 1B + 2B		
	TAG RTU:	(2) 46,500 CFM @ 2.75 ESP (3) SEE NOTES		
		(4) 7.5 HP VFD ON PROP EXHAUST		
		R( )		
		CFM ESP (5) WIRE ALL ANNALOGUE		
	TAG RTU:	SIGNALS TO LVTB (6) LEAVE 12 INCH X		
		12 INCH AREA IN CONTROL BOX FOR FIELD CONTROLLER		
2		RF130-3-F0-1DL : N L L J Ø D G Ø J Ø 1 Ø Ø A X	[redacted]	
		CFM ESP NOTE! (1) TAG# 5A + 5B (2) 46,500 CFM		
	TAG RTU:	@ 2.75 ESP (3) SEE NOTES (4) WIRE ALL		
		ANNALOGUE SIGNALS TO LVTB (5) LEAVE		
		R( )		
		CFM ESP 12 INCH X 12 INCH AREA IN CONTROL		
	TAG RTU:	BOX FOR FIELD CONTROLLER		
		R( )		
		CFM ESP		
	TAG RTU:			
1,200 FT		P U198-O	M/C	

NOTE! (1) SPECIAL EVAP COILS (SEE SOA)
(2) PERFORATED LINERS IN SUPPLY AIR
(3) INSTALL CUSTOMER FURNISHED TEMP SENSORS - O/A - R/A - MIXED AIR
(4) PERFORM SHIP BY 1/8/98
(5) FURNISH + INSTALL DP SWITCH FOR SUPPLY FAN STATUS
(6) FURNISH + INSTALL ISOLATION

Multiplier .35 TOTAL NET (Rep. Cost) $ [redacted]
REP. CONTACT: ___ FREIGHT $ 16,000.00
COMMISSION $ [redacted]
ORDERED BY: ___ TOTAL BILLING $ [redacted]

1997

NO PO ON PO# DELAYS FOR CHG & NYC ...

AAON, Inc. — Estimating Worksheet

Tulsa, Oklahoma • Ph: (918) 583-2266 • Fax: (918) 583-6094

DATE: REVISION 9/30/98 PAGE 2 of 9

NOTE: THIS WORKSHEET IS FOR ESTIMATING PURPOSES ONLY AND IS NOT INTENDED FOR ORDER PROCESSING.

	MARK • RTU No. 1A...	MARK • RTU No. 5A...	MARK • RTU No.	MARK • RTU No.
Model Number – Series	R	R	R	R
	F	F		
Unit Size	110	120		
Voltage	3	3		
Cooling	E0	F0		
Base Unit Price	$ [redacted]	$ [redacted]	$	$
Heating	1D1	1D1		
Heating Price	$ [redacted]	$ [redacted]	$	$
Feature Number – Option / List Price				
1 Outside Air	N [redacted]	N [redacted]		
2 Blower	L [redacted]	L [redacted]		
3 Filter	L [redacted]	L [redacted]		
4	J [redacted]	J [redacted]		
5	0 –	0 –		
6	H [redacted]	H [redacted]		
7	G [redacted]	G [redacted]		
8	A –	A –		
9	J –	J –		
10	Ø –	Ø	Ø	Ø
11	0 –	0		
12	0	0		
13	A [redacted]	A [redacted]		
14 Type	B –	B –		
Total Unit List Price	$ [redacted]	$ [redacted]	$	$
KD	$	$	$	$
SB	$	$	$	$
Accessories	6/14 91.25φ DX COIL	6/14 91.25φDX COIL	INCL.	
	PERF LINERS-SUPPL	PERF. LINER-SUPPL	#3600	
	MOUNT DDC	MOUNT DDC	1450	
	49" SUPPLY FAN	—	750 (RTU - 1A... ONLY)	
	EXH. VFD - 7.5HP	EXH. VFD - 7.5HP	2750	
List Price Ea.	[redacted]	[redacted]		
Qty.	39 [redacted]	36 [redacted]		

8/18
7/9

AAON, INC.
2425 South Yukon
Tulsa, Oklahoma 74107
Phone (918) 583-2266
Fax: (918) 583-6094

AAON, INC.

FAX

TO: Kevin Gabinelli
Gil-Bar

FROM: Natalie Neilson

DATE: 6-30-98

FAX NO: 732-981-0959

PAGES: 1

SUBJECT: RF-130 Special Pricing – SPA#89008

Kevin,

To provide the RF-130 with perforated liners on the supply section is $3,600 list add.
~~To provide the RF-130 with perforated liners on the return section is $3,100 list add.~~

I do not have the pricing for the entire unit, so I will have to research this and get back with you.

Also, I don't know what to tell you on the "Sharing ?" job, you really need to discuss this matter with Steve pagetter. Sorry!!!!

This pricing is valid for use within 30 days of this transmission. Please send in a copy of this letter or the SPA number to expedite the process.

Thank you,

Natalie Neilson
Ext. 293

BM03L5 AC AAON, INC. WIRING DIAGRAM ASSIGNMENT & VERIFICATION 01 Apr 2002 PAGE 1

REQUESTED BY ccox-eng /dev/pts/29

REQUISITION NUMBER: 256816

ORDER INFORMATION
CUSTOMER: FREY LUTZ CORPORATION
SHIP-TO : HARRISBURG, PA 17110
JOB NAME: FARM SHOW ARENA

LEAD DTE: 12/27/01 SHIP ON : 06/30/02

CONTACT : B. SMITH

SEQ	PART NBR	QTY	DESCRIPTION	DISPOSITION
001	@	0	RL-135-3-0-FZ0Q-344: A000E00XB2CP0D00A00J000GB00000X	--no-ENG
002	@	9	RL-230-3-0-0X08-354: BGBEE0DXEUCP0DACB00J00GR00RNOX	EEfrnt 04/01/02 by CCOX-EN
003	@FREIGHT	1		--no-ENG
004	@REP-780	1		--no-ENG

Sales and Engineering text lines for entire order
-----------------SALES HEADER INFO------
NOTE ON JOB SAYS "HOLD FOR APPROVAL" (WRITTEN BY JIM PARRO)
REVISED OPTION #15 FROM [0] TO [A] PER J. PARRO 1/4/02 DS
3/5 PER BRETT S.-SHIP APPROX. 6/30. JL
PER BUCK NYE SHIP UNITS END OF JUNE IF POSSIBLE!!!
-----------------ENG HEADER INFO-------
--------------SALES LINE ITEM # 001-----
1] 38000 CFM @ 1.5 ESP
2] SUPPLY FAN BACK DRAFT DAMPER
3] SPA #101255
4] TAG #1
--------------SALES LINE ITEM # 002-----
1] 42500 CFM @ 2.25 ESP
2] SUPPLY FAN BACK DRAFT DAMPER
3] RA FAN PITCH 40"
4] TAG #1 THRU 9
5] SPA #101255
6] 8 ROW DX COILS
7] (4) COPELAND SCREW COMPRESSORS
8] STAINLESS STEEL CONDENSER FAN MOTOR SHAFT
9] 14 GA. BASE SHEETS
10] BURGLAR BARS ON 3" CENTERS
11] FACTORY INSTALL CUSTOMER PROVIDED CONTROLS
12] MAKE-UP WATER BACKFLOW PREVENTER

RL230
Cooling (4 Screw / Evap cooled cond)
GAS Heat (12 stg (10 Tubes))
2 Power exhaust w/ 2 VFDS
DDC Eco —
2 Supply Fans w/ 2 VFDS
Marine Lights.

AAON, Inc. Worksheet

2425 South Yukon Ave - Tulsa, Oklahoma 74107-2728 - Ph. (918) 583-2266 Fax (918) 583-6094

AAONEcat32 Ver. 4.00 Beta

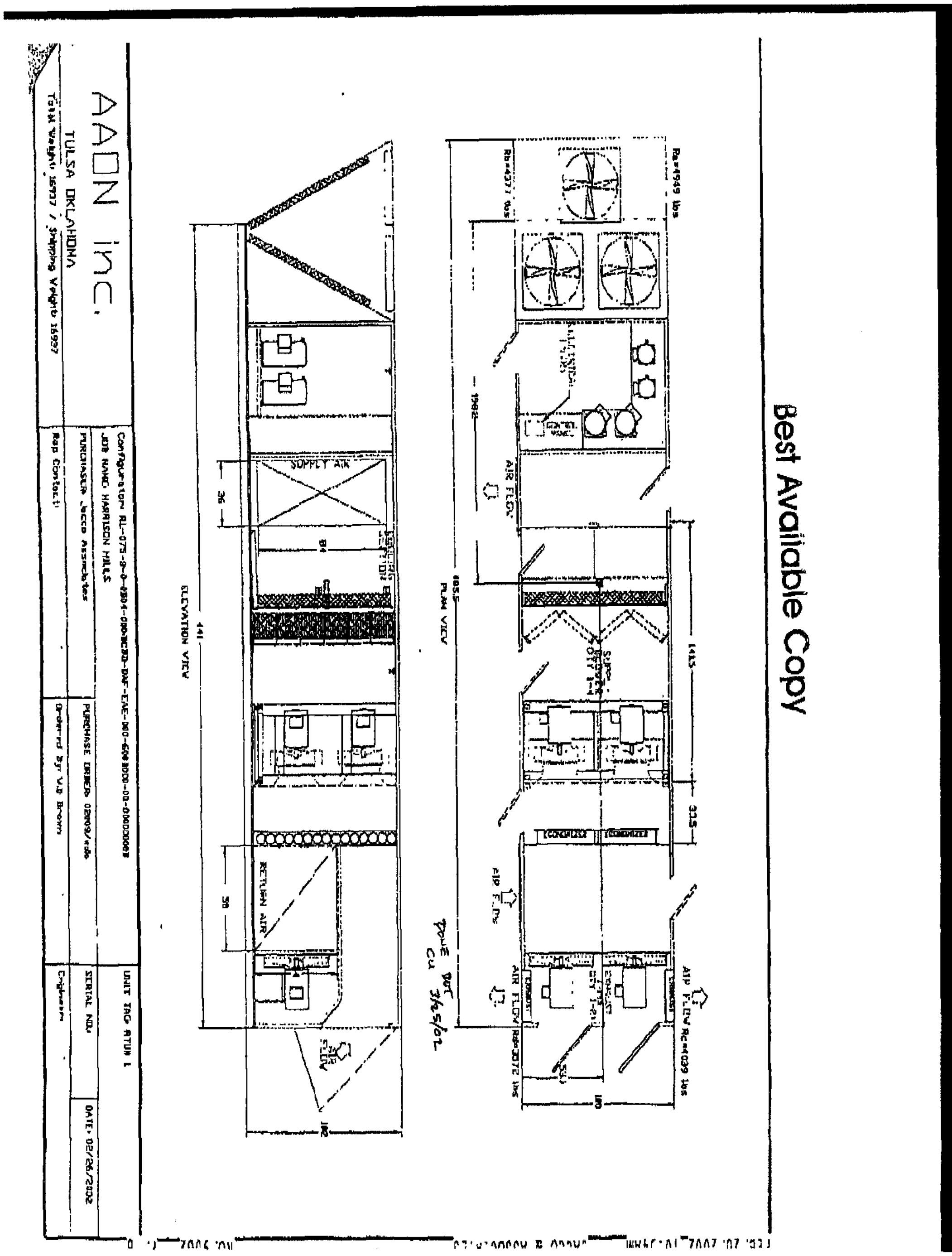
RL-075-8-0-0B04-000:BCBD-DAF-EAE-000-G00B000-00-00000000B

Tag: RTU# 1

Job Name:	HARRISON HILLS	Worksheet For:	Jocco Associates
Job Number:	Job #1	Worksheet Date:	February 26, 2002

	Base Option	Description	List Price	Rep. Price	Cust. Price
R	Series	Roof Top Unit			
L	Generation	Eighth Generation			
075	Size	Seventy Five			
8	Voltage	208V/3Ø/60Hz	[redacted]	[redacted]	[redacted]
0	Interior Protection	Standard	[redacted]	[redacted]	[redacted]
0	Cooling Style	Blow Thru - R22 Dual Circuited Compressors	[redacted]	[redacted]	[redacted]
B	Cooling Configuration	Air Cooled Cond w/ 6R Coil High CFM	[redacted]	[redacted]	[redacted]
0	Cooling Coating	Std	[redacted]	[redacted]	[redacted]
4	Cooling Stages	4 Stage	[redacted]	[redacted]	[redacted]
0	Heating Type	No Heat	[redacted]	[redacted]	[redacted]
0	Heating Designation	No Heat	[redacted]	[redacted]	[redacted]
0	Heating Stages	No Heat	[redacted]	[redacted]	[redacted]

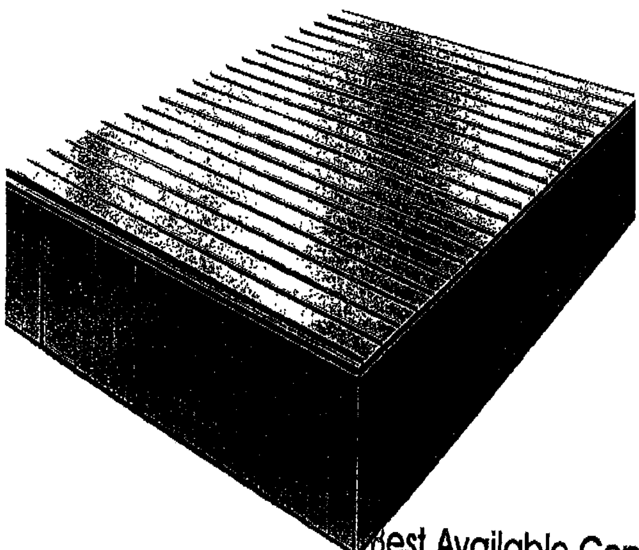
	Feature Option	Description	List Price	Rep. Price	Cust. Price
B	1A.Outside Air Options	Power Exhaust	[redacted]	[redacted]	[redacted]
C	1B.RA Blower Configuration	1 Blower (Prem eff mtr)	[redacted]	[redacted]	[redacted]
B	1C.RA Blower	Blower B (42" Dia 9 Blade)	[redacted]	[redacted]	[redacted]
D	1D.RA Motor	3.0 hp (1170 rpm)	[redacted]	[redacted]	[redacted]
D	2.Outside Air Controls	Full Mod Enthalpy Econ	[redacted]	[redacted]	[redacted]
A	3.Discharge Location	Front Discharge	[redacted]	[redacted]	[redacted]
F	4.Return Location	Front Return High CFM (w/ eco or pwr ex)	[redacted]	[redacted]	[redacted]
E	5A.SA Blower Configuration	2 Blowers w/(Prem eff mtr)	[redacted]	[redacted]	[redacted]
A	5B.SA Blower	Blower A (27" Diameter)	[redacted]	[redacted]	[redacted]
E	5C.SA Motor	5.0 hp (1170 rpm)	[redacted]	[redacted]	[redacted]
0	6A.Pre-Filter	2" Pleated	[redacted]	[redacted]	[redacted]
0	6B.Final Filter	Std	[redacted]	[redacted]	[redacted]
0	6C.Filter Options	Std	[redacted]	[redacted]	[redacted]
G	7.Refrigeration Controls	5 MTDR On & Off + 115V Outlet Factory Wired	[redacted]	[redacted]	[redacted]
0	8.Refrigeration Options	Std	[redacted]	[redacted]	[redacted]
0	9.Refrigeration Accessories	Std	[redacted]	[redacted]	[redacted]
B	10.Power Options	400 Amps Power Switch	[redacted]	[redacted]	[redacted]
0	11.Safety options	Std	[redacted]	[redacted]	[redacted]
0	12.Controls	Std	[redacted]	[redacted]	[redacted]
0	13.Special Controls	Std	[redacted]	[redacted]	[redacted]
0	14A.Pre-Heat Configuration	Std (No Preheat)	[redacted]	[redacted]	[redacted]
0	14B.Pre-Heat Sizing	Std (No Preheat)	[redacted]	[redacted]	[redacted]
0	15.Option Boxes	Std	[redacted]	[redacted]	[redacted]
0	16.Cabinet Options	Std	[redacted]	[redacted]	[redacted]
0	17.Cabinet Options	Std	[redacted]	[redacted]	[redacted]
0	18.Customer Code	Std	[redacted]	[redacted]	[redacted]
0	19.Code Options	Std ETL USA Listing	[redacted]	[redacted]	[redacted]
0	20.Unit Splits	Std (One Piece Unit)	[redacted]	[redacted]	[redacted]
0	21.Evap & Water Condenser	Std (No Evap or Water Condenser)	[redacted]	[redacted]	[redacted]
0	22.Blank	Std	[redacted]	[redacted]	[redacted]
B	23.Type	Std (Includes 'Gray Paint')	[redacted]	[redacted]	[redacted]
		Subtotal	[redacted]	[redacted]	[redacted]
		Quantity	[redacted]		
		Total	[redacted]	[redacted]	[redacted]


AAON inc.
TULSA OKLAHOMA
JOB NAME: HARRISON HILLS
Rep Contact:
SERIAL NO:
DATE: 02/26/2002
ELEVATION VIEW
PLAN VIEW
SUPPLY AIR
RETURN AIR
AIR FLOW
Best Available Copy

Best Available Copy

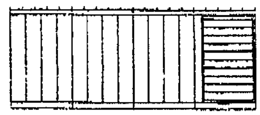
Custom Penthouse

200 – 410 Tons
Cooling-only VAV configurations

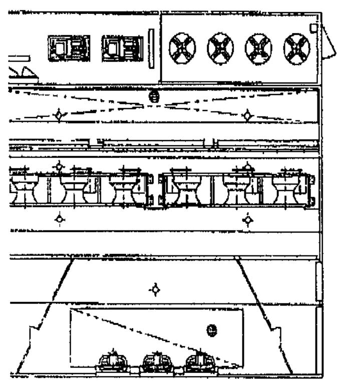


Selection Guide

Look into a Mammoth Custom Penthouse for flexibility, efficiency, and reliability



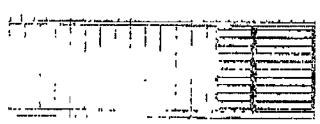
For your next HVAC design, take advantage of lower first costs, shorter construction cycles and time-proven performance. Enjoy complete system flexibility, without the design, procurement and labor costs normally associated with field-built systems.

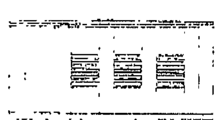


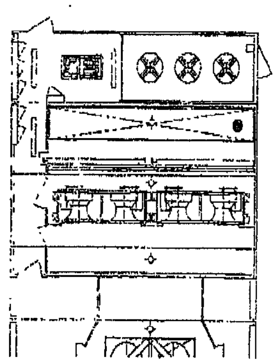
Specify a Mammoth Custom Penthouse

Mammoth has engineered the Custom Penthouse to meet the conditioning needs of office buildings, retail establishments and warehouse/industrial facilities with cooling requirements from 200 to 600 tons.

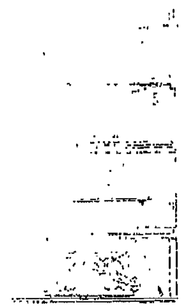
The following data provides an overview of Custom Penthouse configurations and performance characteristics available for variable air volume (VAV), cooling-only applications. If your project requires additional capacity or mechanical equipment, the Custom Penthouse can be engineered to satisfy those requisites. After all, the number of possible options ends only when you are satisfied.



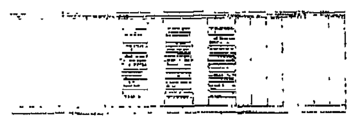


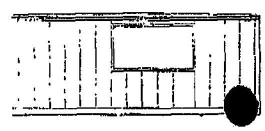


Custom Penthouse standard features



- Evaporative condenser with staging/unloading capability
- York semi-hermetic reciprocating compressors
- Supply and return fan staging
- DX cooling and fan redundancy
- Custom exterior color (air dry)
- Walk-in service vestibule
- Full interior service lighting
- Factory-wired 15-amp GFI convenience outlet
- Remote unit status monitoring panel
- Vari-Cone® air modulator
- Four-inch 30% efficiency filters
- Low-leakage outside/return air dampers
- Full economizer control
- Water treatment interface for condenser
- Single point main and temperature control
- Factory certified start-up
- ETL labeled





Optional features

- Screw compressors
- Factory fabricated, field installed curbing
- Direct digital control (DDC) interface or complete DDC unit controls
- Acoustical inner liner panels
- Access stairways
- Custom-sized DX coils and supply air openings (requires factory confirmation)
- Fire and smoke sequence of operation
- Custom remote control panel
- Factory-certified final field piping/ electrical connections

This is just a sampling of options available for the Mammoth Custom Penthouse. For more information, consult your Mammoth Representative.

UNIT PHYSICAL AND NOMINAL PERFORMANCE DATA

MODEL	Propeller Exhaust						Power Return					
	2102	2602	3002	3502	4203	4403	2102	2602	3002	3502	4203	4403
Condenser KW	164.7	199.8	225.0	275.5	315.0	340.4	164 7	199.8	225.0	275.5	315.0	340.4
Unit Total Full Load Amps (460/3/60)	427.0	555.2	591.6	777.8	858.0	890.0	474 0	579.2	627.6	803.8	892.0	944.0
DX Cooling Capacity												
MBH/Tons Total	2400/200	2940/245	3300/275	3960/330	4560/380	4920/410	2400/200	2940/245	3300/275	3960/330	4560/380	4920/410
Sensible	1825/152	2215/184	2485/207	2985/248	3405/283	3740/311	1825/152	2215/184	2485/207	2985/248	3405/283	3740/311
DX Coil												
Rows/Fins per Inch	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10	5/10
Square Feet	132	157	177	211	241	271	132	157	177	211	241	271
Main Supply Fan Data												
Supply Air CFM	76,000	93,100	104,500	125,400	144,400	155,800	76,000	93,100	104,500	125,400	144,400	155,800
Supply Air TSP ("WC)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5 0
Supply Air Brake HP/ Actual HP	112/120	128/160	148/160	171/240	204/240	222/240	112/120	128/160	148/160	171/240	204/240	222/240
Power Return Air/ Exhaust Air Fan Data												
Return Air CFM	N/A	N/A	N/A	N/A	N/A	N/A	68,400	83,700	94,000	112,800	129,000	140,200
Return Air ESP ("WC)	N/A	N/A	N/A	N/A	N/A	N/A	1.5	1.5	1.5	1.5	1.5	1.5
Return Air Brake HP/ Actual HP	N/A	N/A	N/A	N/A	N/A	N/A	58/60	46/50	55/60	57/60	72/75	83/90
Prop Exhaust Fan Data												
Exhaust Air CFM	68,400	83,700	94,000	112,800	129,000	140,200	N/A	N/A	N/A	N/A	N/A	N/A
Exhaust Air ESP ("WC)	0.50	0.50	0.50	0.50	0 50	0.50	N/A	N/A	N/A	N/A	N/A	N/A
Actual HP	22.5	30.0	30.0	37.5	45.0	45.0	N/A	N/A	N/A	N/A	N/A	N/A
Filters (4")												
35% Eff. – Square Feet	167.0	208.0	208.0	267.0	267 0	333.0	167.0	208.0	208.0	267.0	267.0	333.0
Louver/Damper Data												
Outside Air Louver-Sq Ft	104.0	184.0	184.0	184.0	184 0	184.0	104.0	184.0	184.0	184.0	184.0	184.0
Outside Air Motorized Damper-Sq. Ft.	68.0	93.0	93.0	160.0	160.0	160.0	68.0	93.0	93.0	160.0	160.0	160.0
Return Air Motorized Damper-Sq. Ft.	86.0	103.0	103.0	163.0	163.0	163.0	86.0	103.0	103.0	163.0	163.0	163.0
Exhaust Air Non-Motorized Damper-Sq Ft.	52.0	69.0	69.0	86.0	104.0	104.0	68.0	75.0	75.0	101.0	101.0	101.0
Size - Length x Width	30' x 25'	37½' x 30'	37½' x 30'	37½' x 45'	37½' x 45'	37½' x 45'	30' x 25'	37½' x 30'	37½' x 30'	37½' x 45'	37½' x 45'	37½' x 45'
Operating Weight (lbs.)	43,967	59,352	59,880	80,216	83,208	84,057	44,924	60,405	61,033	81,935	84,742	85,591

DESIGN CRITERIA

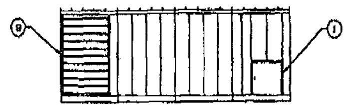
1) All data measured at sea level.
2) Cooling loads based on 80°/67°F entering air temperature to DX cooling coil.
3) DX cooling capacity based on DX saturated suction temperature of 45°F and 76°F entering wet bulb design temperature.
4) All data based upon a Custom Penthouse unit height of 10 feet 4 inches only.
5) For smaller/larger capacity units, please consult your Mammoth representative.

H 000366

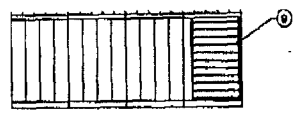
REFERENCE

Propeller Exhaust – Model 2102

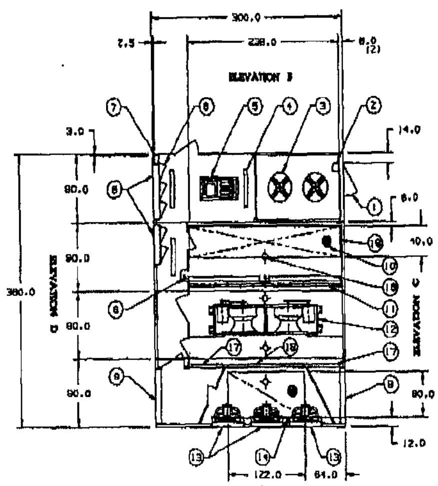
Mammoth®



ELEVATION C

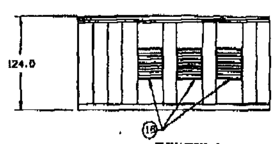


ELEVATION D

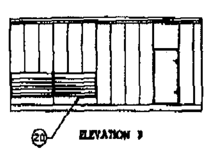


ELEVATION A

ITEM	DESCRIPTION
1	Sump access
2	10" x 10" Supply and drain water chase
3	Condenser fans
4	Fluorescent lights
5	Compressors
6	Control box
7	6" x 12" Electrical chase
8	Evaporator coils
9	Outside air louvers
10	Bar grate
11	4" filters
12	Main supply fans
13	Prop exhaust fans
14	Return opening
15	Exhaust louvers
16	Incandescent vapor proof lights
17	Outside air dampers
18	Return air dampers
19	Supply opening
20	Sump intake



ELEVATION A

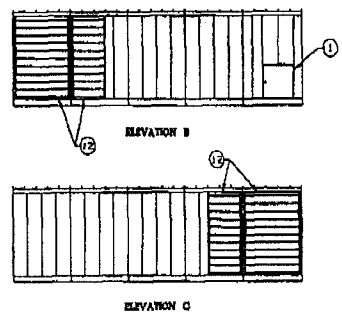


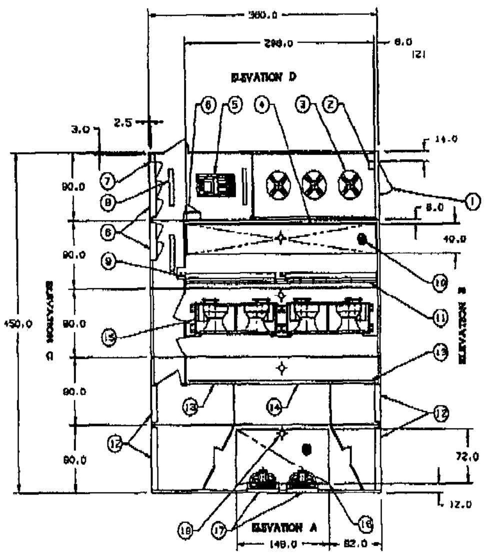
ELEVATION B

REFERENCE

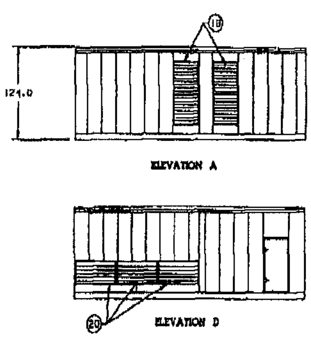
Propeller Exhaust –
Model 2602
Model 3002

Mammoth®





ITEM	DESCRIPTION
1	Sump access
2	10" x 10" Supply and drain water chase
3	Condenser fans
4	Supply opening
5	Compressors
6	Control box
7	6" x 12" Electrical chase
8	Fluorescent lights
9	Evaporator coils
10	Bar grate
11	4" filters
12	Outside air louvers
13	Outside air dampers
14	Return air dampers
15	Supply fans
16	Return opening
17	Prop exhaust fans
18	Exhaust louvers
19	Incandescent vapor proof lights
20	Sump intake

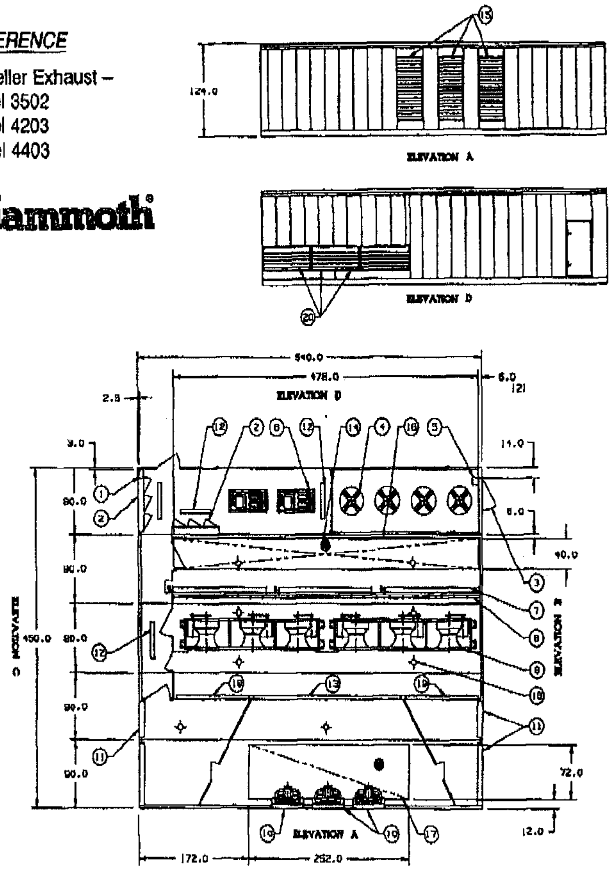


H 000368

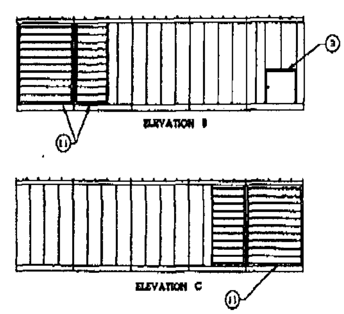
REFERENCE

Propeller Exhaust –
Model 3502
Model 4203
Model 4403

Mammoth®



ITEM	DESCRIPTION
1	6" x 12" Electrical chase
2	Control box
3	Sump access
4	Condenser fans
5	10" x 10" Supply and drain water chase
6	Compressors
7	Evaporator coils
8	4" Filters
9	Supply fans
10	Prop exhaust fans
11	Outside air louvers
12	Fluorescent lights
13	Return air dampers
14	Bar grate
15	Exhaust louvers
16	Supply opening
17	Return opening
18	Incandescent vapor proof lights
19	Outside air dampers
20	Sump intake

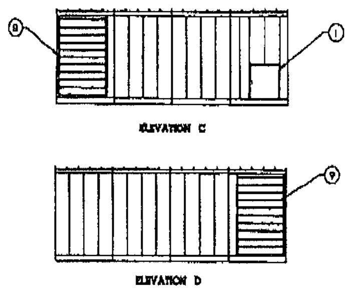


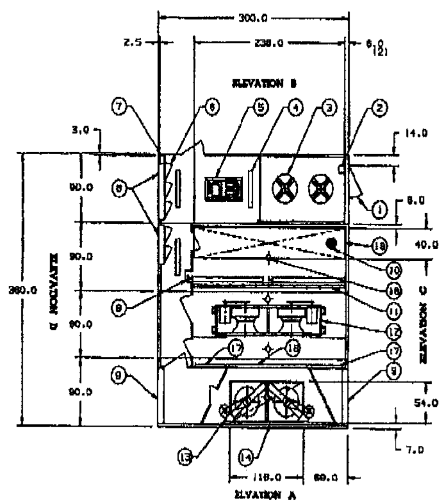
H 000369

REFERENCE

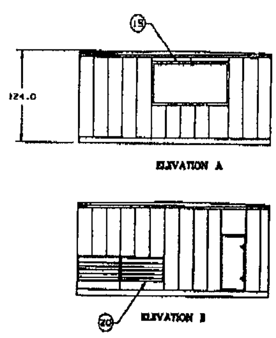
Power Return –
Model 2102

Mammoth®





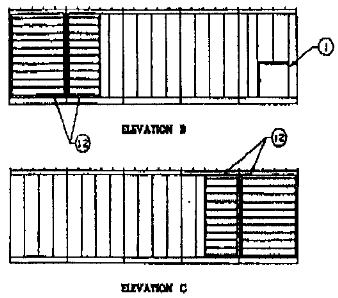
ITEM	DESCRIPTION
1	Sump access
2	10" x 10" Supply and drain water chase
3	Condenser fans
4	Fluorescent lights
5	Compressors
6	Control box
7	6" x 12" Electrical chase
8	Evaporator coils
9	Outside air louvers
10	Bar grate
11	4" filters
12	Supply fans
13	Power return fans
14	Return opening
15	Relief panel
16	Incandescent vapor proof lights
17	Outside air dampers
18	Return air dampers
19	Supply opening
20	Sump intake

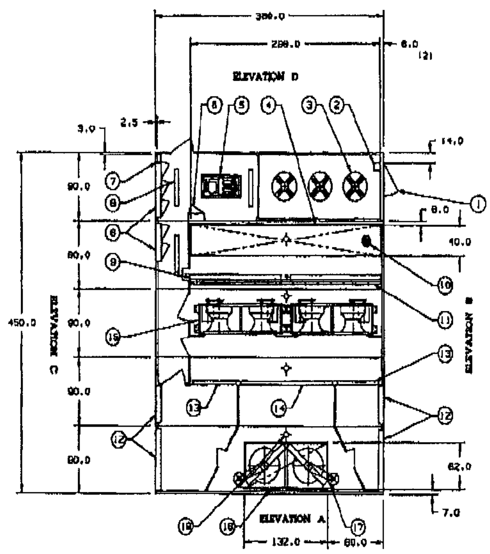


REFERENCE

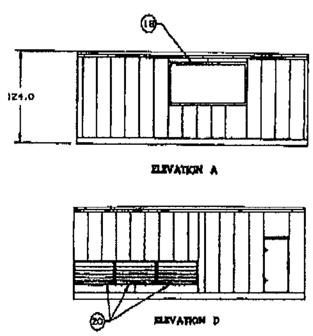
Power Return –
Model 2602
Model 3002

Mammoth





ITEM	DESCRIPTION
1	Sump access
2	10" x 10" Supply and drain water chase
3	Condenser fans
4	Supply opening
5	Compressors
6	Control box
7	8" x 12" Electrical chase
8	Fluorescent lights
9	Evaporator coils
10	Bar grate
11	4" filters
12	Outside air louvers
13	Outside air dampers
14	Return air dampers
15	Supply fans
16	Return opening
17	Power return fans
18	Relief panel
19	Incandescent vapor proof lights
20	Sump intake

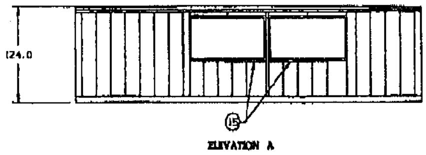


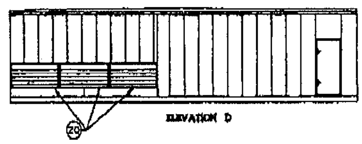
H 000371

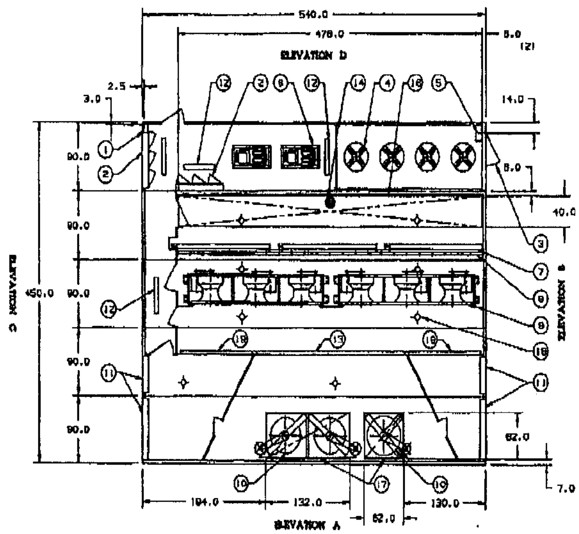
REFERENCE

Power Return –
Model 3502
Model 4203
Model 4403

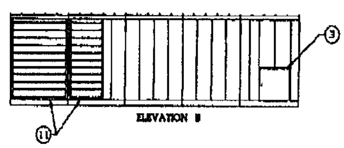
Mammoth®

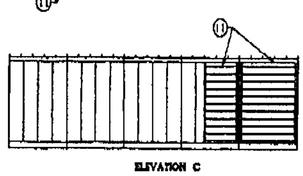






ITEM	DESCRIPTION
1	6" x 12" Electrical chase
2	Control box
3	Sump access
4	Condenser fans
5	10" x 10" Supply and drain water chase
6	Compressors
7	Evaporator coils
8	4" Filters
9	Supply fans
10	Power return fans
11	Outside air louvers
12	Fluorescent lights
13	Return air dampers
14	Bar grate
15	Relief panel
16	Supply opening
17	Return opening
18	Incandescent vapor proof lights
19	Outside air dampers
20	Sump intake





UNIT SPECIFICATIONS

The Penthouse unit shall be Mammoth Custom Penthouse unit of the type, size, and capacity as required and listed in the equipment schedule. Each unit shall include the pre-assembled components in accordance with the following detailed specifications.

Construction

Cabinet

Each Penthouse unit shall be fabricated in one (1) or more sections ready for field installation. Each section shall be fabricated with a structural steel base reinforced and braced to permit the shipping and general handling of the completed section without damage to the section or internal components. The section base shall be fabricated with an 8-inch, 11.5 lb. per foot, structural member perimeter and have 8-, 11-, and 14-gauge formed structural cross members at 30" centers maximum. Additional cross members or reinforcements shall be placed at critical locations to support internal components. The base section shall have a floor of 14-gauge galvanized steel, insulated with 4-inch, 1½ lb. density fiberglass insulation and a 1/2" blanket type, dual-density construction insulation providing acoustical sound absorption capabilities. The insulation shall be retained on the underside by hardware cloth. Lifting points for the section shall be part of the section base.

The section exterior wall structure shall be fabricated of formed 11 and 14-gauge members. The exterior siding shall be 22-gauge pre-painted galvanized steel fabricated and assembled to provide an embossed exterior surface. The wall shall be insulated with 4-inch, 1½ lb. fiberglass insulation for minimum "R" value of 16.3. The interior surface of the wall shall form the air seal and shall be fabricated from 20-gauge galvanized steel. No exposed insulation shall be permitted in the air stream. Foil back or rigid board exposed stick-on insulation will not be permitted.

The top frame structure shall be fabricated of 11- and 14-gauge steel. The interior surface shall form the air seal and shall be fabricated from 20-gauge galvanized steel. The roof shall be insulated with 4-inch, 1½ lb. density fiberglass for minimum "R" value of 16.3. The roof exterior shall be constructed of 18"-wide roll-formed panel, of 24-gauge galvalume material with 2¾" standing seams. The roof shall be sloped a minimum of 2".

Sections shall be designed to be joined together by bolting through mating frame structure. The section frame shall be completely prime painted after fabrication to prevent rusting.

Service Vestibule

Each unit shall be provided with a full-height, internal walk-in service corridor. A double-wall insulated partition shall be used to separate the airflow equipment from the service corridor. The partition shall be fabricated with a 2" structural frame of 14-gauge galvanized steel, 20-gauge galvanized steel skins, and insulated with 2-inch, 1½ lb. fiberglass insulation. The service corridor floor shall be constructed of 12-gauge treadplate.

Doors

The external access door(s), and service corridor access door(s) shall be fabricated with an outer skin of 18-gauge galvanized steel, an inner skin of 20-gauge galvanized steel and insulated with 2-inch, 1½ lb. fiberglass insulation. The door shall have a continuous hinge mounted to a 12-gauge door frame. A continuous vinyl bulb gasket shall seal between the door and frame. The access door(s) shall be secured with latches which are operable from both sides. External vestibule access door(s) shall be 36" x 75¾". Other access door(s) shall be 24" x 75¾". Internal access door(s) serving the airstream shall be provided with 6" x 6" sight ports.

DX Cooling

Compressors

The compressors shall be of the semi-hermetic, reciprocating type, operating at no more than 1750 RPM, refrigerant gas-cooled, with three-phase inherent overload protection, with voltage available at 460-480 Volts, and "UL" listed.

Lubrication is force-fed by a self-priming reversible, gear-type oil pump to all crankcase surfaces through a fine mesh stainless steel oil strainer, with relief internal to housing conforming to ASHRAE/ANSI Code. A 350-Watt crankcase oil heater shall be supplied to maintain oil temperature during shutdown periods. Tight-seating suction and discharge stop valves are seal cap-type with pressure taps and sweat-type flanged adapters.

Capacity-reduction is accomplished by an oil pressure-actuated cylinder unloading solenoid valve located on compressor crankcase cover plate. Solenoids are controlled by Mammoth factory controls with all compressors capable of four steps of capacity control.

Compressors are tested at 330 PSI with the discharge side further tested to 450 PSI and charged with oil and R-22 to assure a sealed and dry system before final field connections are made.

Evaporative Condenser

The evaporative condenser coils shall have all prime surface staggered copper tubes, copper headers, and ABS tube sheets to allow for expansion and contraction while avoiding galvanic corrosion. A subcooler integral to the condenser coil shall provide a minimum of 10° F. liquid subcooling. The coils shall be factory leak tested at 400 PSIG nitrogen under water.

The sump shall be constructed of welded 14-gauge type 304L stainless steel below water level and 20-gauge type 430 stainless steel above water line. The sump shall be equipped with a non-mechanical electronic water level control with a brass solenoid valve in the fill line for positive shutoff. A manual 2" brass drain valve, and electric pipe heating cable shall be provided.

The water circulating pump shall be a close coupled, bronze fitted centrifugal type with mechanical seal. Pump suction and discharge lines shall have flexible connections. A type 304 stainless steel pump suction strainer shall be provided which is easily removed for cleaning. The spray header shall be PVC with non-clogging brass spray nozzles, which thoroughly wet all coil surfaces to give maximum heat transfer and minimum scaling. An automatic, factory-set, field-adjustable sump water bleed shall be provided. Units shall be factory piped and tested, ready for 1¼" supply water and 2" drain line hookup.

H 000373

Evaporator

The direct expansion evaporator coils shall be fabricated from staggered 1/2" O.D. x .017 wall seamless copper tubing expanded into plate-type aluminum fins to form a positive mechanical and thermal bond. The fins shall have full drawn collars to completely cover the copper tubes. They shall be factory leak tested at a minimum of 400 PSIG under water. Evaporator coils shall be provided with thermostatic expansion valves equipped with external equalizer lines and adjustable for superheat. Refrigerant shall be fed to the coil circuits by brass distributors.

Each evaporator coil shall be provided with a drain pan which shall be fabricated of galvanized sheet steel and coated with corrosion resistant mastic material, which shall be fire resistant (shall meet wet flammability per ASTM D93-73 and dry flammability per ASTM E84-70), provide vibration dampening and thermal insulation. The drain pan(s) shall extend beyond the leaving side of the coil and underneath the cooling coil connections and shall have a common threaded condensate drain connection extending through the unit base frame.

Refrigerant Circuits

The refrigerant circuits shall be multiple independent circuits which shall be factory piped, tested, dehydrated and fully charged with oil and refrigerant R-22 (holding charge only). Field connections are required between sections. Each refrigerant circuit shall include liquid line service and charging valves, removable core filter drier, sight glass, liquid line solenoid valve, suction and discharge line check valves and compressor service valves.

Supply Air Fans

Airfoil Fans

The fan wheels shall be multiple airfoil, single width/single inlet-SAS type, secured to a machined, ground and polished solid steel shaft. The shaft shall be coated with a rust inhibitor and shall be supported by two outboard bearings. The fan assembly shall be dynamically balanced. Bearings shall be of the self-aligning ball bearing pillow block type and shall be designed for a minimum of 200,000 hours average life. Drive shall be by means of multiple V-belts. Motor and fan assembly shall be mounted on a heavy-duty steel frame supported by springs with 1-inch deflection (2-inch deflection available).

Variable Air Volume – Varicone®

The unit shall be capable of delivering a variable air volume by means of a conical spun-steel disk which slides through each fan inlet cone to modulate air flow from 100% open to a tight shut off. The disk is mounted on a rigid stainless steel sleeve with graphite impregnated bearings between it and the fan wheel shaft. Neither the sleeve assembly nor the control disk rotate. Position control is attained by the use of a non-binding ball-and-screw activator.

Outside And Return Air Dampers

Dampers are mounted within a 14-gauge galvanized die-formed channel. The construction of the airfoil shaped blade is of extruded aluminum double wall, with a 1/2 inch, 16-gauge plated square tube axle, keyed into the 12-gauge screw compression pivot arms. Cross linkage rails are fabricated from 12-gauge galvanized 1¼ x ¼ inch angle. Pivot bearings 3/4 x 3/16 inch plated steel. The axle bushings shall be injected molded from delrin. All blade edges are extruded with inflatable tip, fully operational in ambient conditions ranging from -50° F to 275° F. The leakage rate shall be 1.90 CFM at 1.0 (inches WC) to 5.2 CFM per each square foot of damper area at 4.0 (inches WC) static pressure across blade surface.

Outside Air Intake Louvers

Outside air louvers shall be of a storm-proof design and shall be provided with 1/2" x 1/2" galvanized bird screen. A fully insulated divider shall be provided to separate outside air from return air.

Power Return/Exhaust Fans

Airfoil Fans

The fan wheels shall be multiple airfoil, single width/single inlet-SAS type secured to a machined, ground and polished solid steel shaft. The shaft shall be coated with a rust inhibitor and shall be supported by two outboard bearings. The fan assembly shall be dynamically balanced. Bearings shall be of the self-aligning ball bearing pillow block type and shall be designed for a minimum of 200,000 hours average life. Drive shall be by means of multiple V-belts. Motors shall be heavy-duty open drip-proof, three-phase, 1800 RPM, mounted on a heavy-duty sliding base. Motor and fan assembly shall be mounted on a heavy-duty steel frame supported by springs with 1-inch deflection (2-inch deflection available). Exhaust air discharge through a non-motorized, fully-insulated gravity relief panel.

Propeller Exhaust Air

Propeller exhaust fans shall each have six die-formed blades welded to a steel hub assembly. Gussets which extend three-quarters of the blade length are welded to the blades to reinforce, strengthen and prevent twisting and loss of shape under load. Each fan shall be belt-drive. Shaft bearings are pillow block type. An exhaust air non-motorized backdraft damper shall be supplied with each fan.

Filters

The units shall be provided with filters installed in a galvanized steel filter rack. The filters shall be 4-inch 30% efficiency (ASHRAE 52-76 Standards) throwaway type. The filters shall be provided with easy access for insertion and removal.

Unit Main Disconnect Switch

The unit shall be furnished with a molded case switch (non-automatic circuit breaker) to disconnect the power supply. The design shall incorporate a switch handle to permit unit disconnect without opening the control panel doors.

Main Control Panel

The main control panel shall have an access door for direct access to the controls. The panel shall be equivalent to NEMA type 3R (rainproof) and shall contain a single, externally operated, molded case switch (non-automatic circuit breaker) suitable for copper wire up to and including 3-inch conduit. Wire and conduit entrance shall be inside of unit curbing. The main control panel shall include the following:

1. A power terminal block.
2. A power transformer with 115-Volt secondary transformer and 115-Volt circuit breakers.
3. A 24-Volt control transformer and circuit breakers.
4. Necessary relays.
5. A 115-Volt terminal strip.
6. A 24-Volt terminal strip which shall contain wired terminals for all controls, numbered in accordance with the wiring diagram.
7. An isolated 24-Volt field wiring terminal strip.
8. An electric print pocket which in addition to the electric print shall contain a pre-startup form, a startup form and maintenance instructions.

The above components shall be in addition to electrical components associated with other sections, which shall be incorporated in the main control panel to facilitate maintenance and trouble-shooting. All components shall be identified with name tags and wired in accordance with National Electric Code.

Temperature SST Controls, Variable Air Volume (VAV) Cooling

Each unit shall be furnished complete with all operational controls. All controls in the basic control package shall be factory installed and wired. The control system shall be a solid state integrated system consisting of a master control sequencer, a discharge air temperature sensor, and a 24-Volt control transformer. The discharge air sensor shall have a platinum resistance-type element which shall sense average discharge air temperature and send a ramp signal to the master control sequencer. The master control sequencer shall accept the signal and initiate stages cooling in proper sequence to maintain a constant discharge air temperature. The master control sequencer shall provide a variable time delay between cooling stages to prevent compressor short cycling.

The economizer control system shall include a modulating spring return, outside air/return air damper actuators, and an enthalpy/sensible changeover control. The enthalpy/sensible changeover control shall determine the capability of the outdoor air to provide free cooling. On a call for cooling, the master control sequencer shall modulate the economizer damper actuators to maintain the discharge air temperature at the effective set point. If this does not meet the space demand, the discharge air sensor shall cause the master control sequencer to energize the required amount of mechanical cooling. The economizer cycle shall allow only enough outside air to maintain the discharge air conditions. If the ambient conditions rise above the enthalpy/sensible changeover control set point, the economizer shall return to the minimum outside air position. The economizer shall have a minimum position potentiometer mounted in the economizer damper actuator.

Remote Status Panel

A remote light indication room panel shall be supplied with each unit. The remote panel shall be supplied complete with the following:

1. Fan-on light
2. Cooling-on light
3. High head pressure failure light
4. Low suction pressure failure light
5. Oil pressure failure light
6. Service (change out) filter light

ES-3-CPH-292

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Woods Practical Guide

to Fan Engineering

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Published by
WOODS OF COLCHESTER LIMITED
Founded 1909
An associate Company of the General Electric Co. Ltd. of England

First published July 1952
Second impression November 1952
Third Impression September 1954
Fourth impression February 1956
Fifth impression June 1957
Sixth impression October 1957

SECOND EDITION
June 1960
Second impression March 1961
Third impression August 1964

MADE AND PRINTED IN ENGLAND BY
BENHAM AND COMPANY LIMITED
COLCHESTER

SECTION 15

Fans

THE DEFINITION of a fan is a machine which propels air continuously by aerodynamic action. Piston-type compressors and positive displacement machines in general are not classed as fans. There are three basic types of fans: centrifugal, propeller, and axial flow. The last two are sometimes regarded as a single group, but the differences in their design and characteristics are such that separate classification is warranted.

Desk and ceiling fans are actually of a propeller type, but are not generally included in that category. They do not come into the field of fan engineering proper and are not dealt with in this publication.

CENTRIFUGAL FANS

The centrifugal fan comprises an impeller which rotates in a casing shaped like a scroll as illustrated in fig. 15-1. The impeller has a number of blades or plates around its periphery, similar to a water wheel or the paddle wheel of some shallow draught river steamers. The casing has an inlet on the axis of the wheel and an outlet at right-angles to it as shown in fig. 15-2. When the impeller rotates the blades at its periphery throw off air centrifugally in a direction following the rotation. The air thrown off into the scroll is forced out of the outlet as more and more leaves the blades. At the same time air is sucked into the inlet to replace that which is discharged. The air enters axially, turns at right-angles through the blades, and is discharged radially. The purpose of the scroll is to convert the high velocity pressure at the blade tips into static pressure.

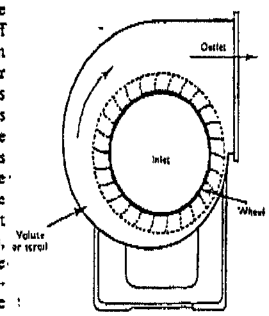

Fig. 15-1. General arrangement of centrifugal fan

FAN PERFORMANCE

Fans are selected to give a certain quantity of air against a certain pressure and their performance must be defined largely by these two factors. Although designed for optimum performance at a given duty, a fan is capable of working quite reasonably over a range of pressures and volumes, and its performance is more completely defined by a table, or graph of pressure and volume flow of air. This is known as the "characteristic" of the fan. Fig. 15-24 shows a typical pressure-volume characteristic of a 24in. diameter Aerofoil fan with a blade angle of 24° running

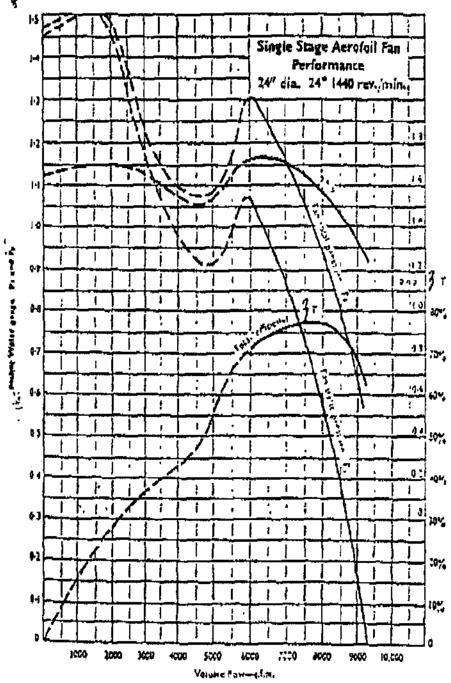

Fig. 15-24. Pressure-volume characteristic of a single-stage axial flow fan

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at 1440 rev/min, with additional curves of b.h.p. and fan total efficiency to complete the information. The efficiency curve shown is based on fan total pressure as this is a measure of the total work done on the air.

The relationship between volume, pressure, power and efficiency may conveniently be stated as below, using the following symbols:

Q	...	Volume flow of air in unit time—c.f.m.
P_T	...	Fan total pressure—in. w.g.
P_S	...	Fan static pressure—in. w.g.
b.h.p.	...	horse-power absorbed by fan.
η_S	...	Fan static efficiency.
η_T	...	Fan total efficiency.

b.h.p. absorbed by fan

$$= \frac{\text{Volume flow of air, Q c.f.m.} \times \text{fan total pressure, } P_T \text{ in. w.g.}}{6350 \times \text{fan total efficiency}}$$

$$= \frac{\text{Volume flow of air, Q c.f.m.} \times \text{fan static pressure, } P_S \text{ in. w.g.}}{6350 \times \text{fan static efficiency}}$$

from which may be derived the relationship

$$\frac{\text{fan static efficiency } \eta_S}{\text{fan total efficiency } \eta_T} = \frac{\text{fan static pressure } P_S}{\text{fan total pressure } P_T}$$

for the same volume flow of air.

Fan laws

Fans are usually made in ranges of size and speed and if, in a given range, each one is identical in all other respects than size to the others, the fans are said to be "geometrically similar". Certain laws govern the relative performance of these fans when working at the same point on the pressure-volume characteristic and may be stated briefly as follows:

With constant impeller size.

1. Volume flow varies directly as the speed of rotation.
2. Pressure developed varies as $(\text{speed of rotation})^2$.
3. b.h.p. absorbed varies as $(\text{speed of rotation})^3$.

With constant speed of rotation.

4. Volume flow varies as $(\text{impeller size})^3$.
5. Pressure developed varies as $(\text{impeller size})^2$.
6. b.h.p. absorbed varies as $(\text{impeller size})^5$.

Consequently with varying speed of rotation and impeller size.

7. Volume flow varies as $(\text{speed of rotation}) \times (\text{impeller size})^3$.

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of air density ρ. The constant now is known as K_S or K_T according to whether comparison is being made on static or total pressure.

$$\therefore \text{ Static fan pressure } P_S = K_S \times \left(\frac{n}{1000}\right)^2 \times (d \text{ in ft.})^2 \times \rho_S$$

$$\text{Total fan pressure } P_T = K_T \times \left(\frac{n}{1000}\right)^2 \times (d \text{ in ft.})^2 \times \rho_S$$

$$\text{Similarly b.h.p.} = K_P \times \left(\frac{n}{1000}\right)^3 \times (d \text{ in ft.})^5 \times \rho_S$$

K_Q, K_S and K_T, and K_P represent the volume flow, pressure and b.h.p. of a one ft. dia. fan running at 1000 rev/min with air at standard density. From the equations on page 138 it follows that:

$$K_P = \frac{K_Q \times K_S}{6350 \times \eta_S} \quad \text{where } \eta_S = \text{fan static efficiency}$$

$$= \frac{K_Q \times K_T}{6350 \times \eta_T} \quad \text{where } \eta_T = \text{fan total efficiency}$$

If fan performance is now plotted in terms of K_Q, K_S, K_T, and K_P instead of volume flow, fan static, and total pressures, and b.h.p. a basis of comparison between fans of different series is readily available, the shape of the "standard" characteristic being in every way identical with that of any fan of the same series. Figs. 15–25 and 15–26 show the characteristics of a type J Aerofoil fan, one of 24in. diameter running at 1440 rev/min and the other in terms of coefficients K_Q and K_S.

REVERSIBILITY OF FANS

In many ventilating and air circulating systems it is desirable at some time to reverse the direction of air flow. Sometimes this is done as an emergency measure, and in some cases to prevent stagnation of air in such places as ships' cargo spaces and refrigerated spaces.

If centrifugal fans are employed reversal will entail a rather complicated system of ductwork, which provides by means of doors an alternative path for the air. Reversal of air flow from centrifugal fans is impossible by any other means, as they are essentially non-reversible.

Propeller and axial flow fans are, however, essentially reversible fans, though, depending upon the individual design, some are more effective than others. Reversal of air flow is simply achieved by reversing the direction of rotation and in the case of electrically driven fans, by means of a switch. This method may be applied to non-guide-vane single-stage fans and to contra-rotating fans, but fans with guide vanes are generally unsuited to this method of reversal.

With the usual types of propeller and axial flow fans, a reduced volume is delivered when the impeller runs in the reverse direction, and is generally from 70% to 75% for propeller and single stage fans and 65% to 70% of the forward volume for contra-rotating fans when operating on the same system of ductwork.

Where equal volume is required in both directions, special fans such as truly reversible Aerofoil fans can be constructed. These have the impeller blades assembled with aerofoil sections set alternately in opposite directions. Thus, whichever way the impeller rotates the conditions of running are the same, and therefore the same volume flow of air results.

It is obvious that some reduction in performance compared with the air delivery given by the standard design is inevitable, but this reduction is not great. For instance, by comparison with a standard Aerofoil fan of the same size and speed, a Truly Reversible Aerofoil fan will deliver about 85% of the volume against about 70% of the pressure. The total efficiency of such a fan is quite high, being 60% to 65%, compared with 70% to 78% of the comparable standard fan.

OPERATION OF FANS IN PARALLEL

Identical fans may be operated quite satisfactorily in parallel when two such fans will deliver twice the volume of air at the same pressure as a single unit. Non-identical fans, too, may be operated in parallel, but care must be taken to select a good working position on the combined characteristic and even then maximum efficiency is unlikely to be achieved at the same time by each fan.

If, as in the case of an axial flow fan of high blade pitch angle, stalling characteristics are exhibited at high pressure, the combined unit will also

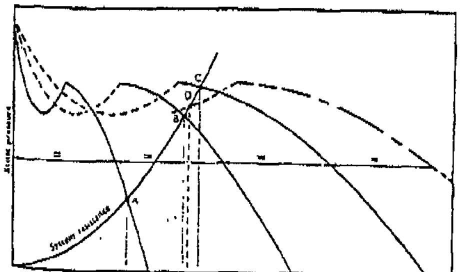

Fig. 15–27. Volume and pressure characteristics of fans in parallel

exhibit these characteristics. Consequently, care must be taken in selection of fans for parallel operation to avoid this possibility. The danger is probably greatest when it is desired to add another fan to the system, in which case, as is illustrated on page 147 by point D, the point of working on the combined characteristic may easily be changed from a perfectly satisfactory one to a very unsatisfactory one.

Two fans operating on the same system, it should be noted, do not give twice as much air as one of them would give when working alone on the system. As the resistance of the system usually increases as the (volume flow of air)^2, the latter settles down at some value which is less than twice the volume given by one fan. The increase in volume per extra fan decreases as the number of fans working in parallel is increased.

A form of volume control is feasible by switching off one or more units, but generally it will be necessary to provide anti-backdraught devices to prevent short circuiting of the air back through the fans not in use.

Fans are usually operated in parallel when lack of space forbids erection of a single large fan. Sometimes, too, a number of small fans may be installed at a lower capital expenditure than a single unit capable of the combined duty. Moreover, the risk of complete shut down is minimised as individual fans may be taken out of service for maintenance without closing down the system, provided shutters are available for blanking off the apertures of the shut-down fans.

VOLUME REGULATION OF FANS

In many fan systems some control of the volume flow of air is desirable. This may be done by any one of many methods, though some methods are much more desirable than others. From the point of view of power consumption, the ideal method is to vary the speed of the fan, although in practice even this cannot be achieved without some loss of power. Fig. 15–29 gives an idea of the relative merits of the following types of volume control compared on a power consumption basis with the ideal method of speed regulation.

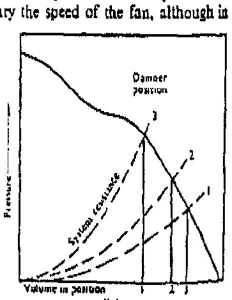

Fig. 15–28. Effect of damper control

Damper control

This is a method very widely used as it is provided by some simple method of throttling the air flow in the system. In other words, the system resistance is varied by

frequency distribution of the main fan will be lower than that of a fan designed to supply a single 9in. × 9in. duct. The sound power level at each outlet is therefore:

$$79 - 9 - 1 - 2 = 67 \text{ dB}p.$$

Sound absorbers

Proprietary absorbers or silencers usually sub-divide the area available for air flow into several passages each lined with perforated sheet backed by rock-wool, glass fibre or some other sound-absorbing material. The attenuation in decibels should be quoted, preferably in octave bands of frequency so that the degree of match with the frequency distribution of the fan may be gauged. Resistance to air flow must also be considered since it is clearly unsatisfactory to absorb so much pressure (inches w.g.) that the fan speed has to be put up, thereby generating more sound and incurring additional power consumption.

Absorbers may be built to suit an installation by inserting into the duct splitters having perforated walls and packed with absorbent material. To be effective on both faces the splitter needs to be twice the thickness of the equivalent duct lining. The benefit obtained from the use of splitters lies primarily in reduction of length since the same amount of absorbent material used as a simple lining may be equally effective if the necessary length is available.

Fig. 18–9 shows some examples of lined ducts which will pass equal volumes of air for the same pressure drop, and will also provide equal noise reduction according to the formula usually employed. This may be written:

$$dB = 4{\cdot}2\,\alpha^{1{\cdot}4} L\,(4A/P)$$

L = Length in direction of air flow, in.

P = Perimeter of cross-section, in.

A = Area of cross-section, sq. in.

4A/P = Diameter of equivalent circular section,

= Length of side of square section,

= Twice width of very elongated rectangular section.

α is not simply the normal absorption coefficient of the particular lining employed. It is also a complex function of the shape and size of the duct and the sound frequency. Fig. 18–10 illustrates some effective values of $\alpha^{1{\cdot}4}$ which have been found experimentally.

SECTION 20

Backdraught prevention

THE EFFECT of opposing winds must be considered when fans exhaust to atmosphere through a hole in a wall. Wind blowing against a fan outlet may restrict the air output and also cause objectionable draughts through the fan aperture. For both these reasons it is advisable to protect the fan with a shutter or cowl.

There are two types of automatic shutter for preventing backdraught when the fan is switched off—louvre and butterfly. The louvre shutter is the cheaper of the two, but its suitability is somewhat limited. This type comprises metal vanes pivoted in a steel ring, as illustrated in fig. 20-1. The vanes are opened by the fan draught and they close by gravity when the fan draught stops. To prevent undue restriction of air output the vanes must open to a minimum angle of 60 degrees. This normally requires a velocity of 1000ft. to 1200ft. per minute. If the discharge velocity is less than shutter vanes will not open sufficiently and the fan output will be restricted. Louvre shutters are therefore not suitable for fans with low outlet velocities. Nor are they to be recommended for high speed fans. The reason for this is that high velocities through the shutter make the vanes rattle. Due to this they may be objectionably noisy, and in the course of time they may even disintegrate. As a general rule louvre shutters are recommended for fan output velocities between 1200ft. and 1500ft. per minute.

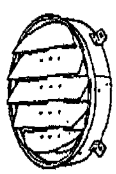

Fig. 20-1.
Louvre shutter

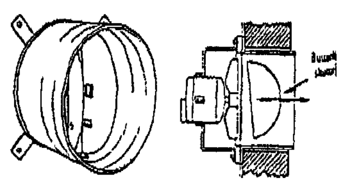

Fig. 20-2. Butterfly shutter

The butterfly shutter does not present the same limitations. This comprises a cylindrical barrel in which two semi-circular flaps are pivoted at an angle. The flaps open in the fan draught and close by gravity when the fan

Selecting Fans, Determining Airflow for Crop Drying, Cooling, Storage

College of Agricultural, Food, and Environmental Science

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Using fans to force air having the proper temperature and relative humidity through a crop is a valuable technique for maintaining quality after harvest. The air helps maintain the moisture, temperature, and oxygen content of a crop at levels that prevent growth of harmful bacteria and fungi and excessive shrinkage.

This fact sheet provides information that will help you select new fans for crop drying, cooling, or storage facilities, or help you determine airflow delivered by existing fans. Grains and oilseeds are the primary crops discussed, but hay, potatoes, and other types of produce are also mentioned.

Airflow Requirements

Total airflow provided by a fan is usually expressed as cubic feet of air per minute (cfm). Recommendations for drying or aerating a particular crop are given as airflow per unit of crop being served by the fan. For example, cfm per bushel (cfm/bu) is used for drying or aerating grains and oilseeds. Typical airflow recommendations are listed in Table 1. Select fans that deliver airflow within the ranges given in the table: greater airflows require larger fans and lead to greater costs, while lower airflows could result in unacceptable crop quality.

Airflow Resistance

Crops

When air is forced through a bulk crop, it must travel through narrow paths between individual particles. For packaged crops, air must travel through or between individual containers. Friction along air paths creates resistance to airflow. Fans must develop enough pressure to overcome this resistance and move air through the crop.

Airflow resistance and fan pressure are usually expressed in inches of water column (in. water, or in. H_2O). This term comes from gages called u-tube manometers that are sometimes used to measure pressure (Figure 1). You can make a u-tube manometer by fastening a clear plastic tube and a ruler to a board. Then pour some water, or water plus a small amount of antifreeze, into the tube. Since manometers are used to measure pressure relative to atmospheric pressure, leave one end of the tube open to the atmosphere. Attach the other end to the duct or plenum where you want to measure pressure. When a fan generates pressure, it forces water in the tube to move in the direction of lower pressure. The height difference of the water levels on the two sides of the tube, measured in inches, is the fan static pressure, in. water. In negative pressure or suction systems, pressure between the crop and the fan is less than atmospheric pressure and water in the manometer tube moves toward the fan. In positive pressure systems, water moves away from the fan. You can buy dial-type pressure gauges that operate on a different principle but that are calibrated to give readings in. water.

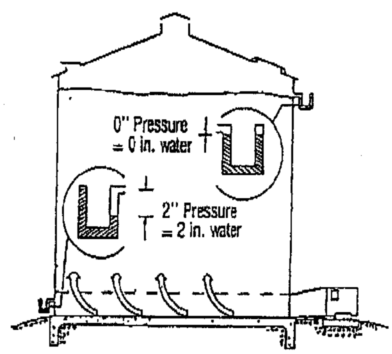

Figure 1. Using a u-tube manometer to measure pressure in a grain bin.

The airflow resistance of a crop and the fan pressure required to overcome it depend on how fast the air is moving and how long and narrow the paths are. For grains and oilseeds, these factors are a function of the particular crop (size and shape of seeds), crop depth, and airflow rate (cfm/bu) you're trying to provide.

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As you can see from Tables 2 through 6, at a given airflow rate, crop depth has a large effect on static pressure. Static pressure, in turn, greatly affects fan power requirements. Short, large diameter bins are recommended for natural-air grain drying because static pressure and required fan size are smaller than they would be in tall, narrow bins. Even though short bins cost more to install than tall ones that have the same grain capacity, total drying costs are less because smaller fans use less electricity.

Airflow resistance of hay, potatoes, and other produce also depends on crop depth or thickness of the layer to be ventilated and airflow rate. For packaged produce, the type of container and the way containers are stacked can also make a difference. But in most cases, airflow resistance of these crops seldom requires fan pressure greater than about 1 in. water. If better information is lacking, use 1 in. as a static pressure estimate for these crops.

Floors and Ducts

The full perforated floors used in grain bins generally have negligible resistance to airflow. Airflow resistance of bin floors isn't significant unless open area is less than about 7%; most commercially available floors have more than 10% open area.

Air supply ducts, tunnels, and perforated air distribution ducts offer greater resistance to airflow than do full perforated floors. This resistance can be quite large if ducts are too small or too long. Use ducts that are large enough that air velocity is less than about 1500 feet per minute. (Divide duct airflow in cfm by duct cross sectional area in square feet to get velocity.) Also, try to keep duct length less than 100 ft. Unless you have better information, use 0.5 in. water as an estimate of airflow resistance for duct systems. Be aware that corrugated plastic ducts designed for air distribution have only 1 to 3% open area, and ordinary plastic tile designed for field drainage has less than 1% open area. Because plastic ducts have so little area for air exit, their airflow resistance can exceed 0.5 in. water.

Air inlet and exhaust openings

When outdoor air is used to ventilate a bin or building, you need to provide adequately-sized openings for air to move in and out of the structure. If openings are too small, they restrict airflow and increase fan pressure requirements. Provide at least one square foot of inlet area per 1000 cfm and an equal exhaust area, and make sure these vents or doors are open anytime the fan is operating.

Fan Performance

Because of the way fan impellers (blades or rotors) are designed, the amount of air they can move decreases as the pressure they are working against increases. The airflow vs. pressure information for a particular fan is called the fan performance data. Performance depends on the size, shape, and speed of the impeller, and the size of the motor driving it. Performance differs widely among brands and models, even for fans with the same size motor.

Access to fan performance data is essential for selecting fans and for determining airflow provided by existing fans. Most manufacturers sell fans that have been tested using procedures specified by the Air Movement and Control Association International, Inc. (AMCA). The manufacturers can provide you with performance data in the form of tables or graphs. Avoid fans for which AMCA data is not available. Table 7 is an example of the type of data you need. Figure 2 is a graphical presentation of the data for two fans from Table 7 that have the same size motor. Note how much performance of the two fans differs.

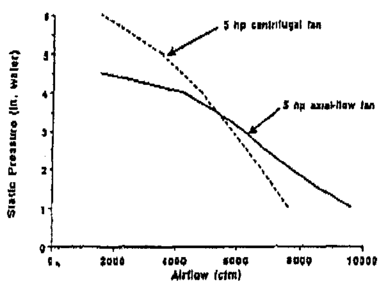


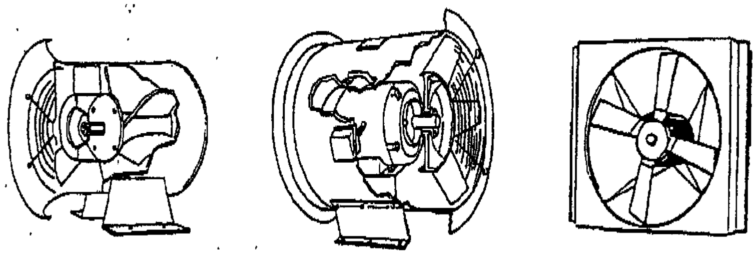
Figure 2. Fan performance data for MES Fans #7 and #10 from Table 7.

Fan Types

Most fans can be categorized as either axial-flow or centrifugal (see Figure 3). Axial-flow fans are sometimes called propeller fans, although that's really just one type of axial-flow fan. Air moves in a straight line through axial-flow fans parallel to the axis or impeller shaft. The impeller has a number of blades attached to a central hub.

Centrifugal fans are sometimes called blowers or squirrel cage fans. The impeller is a wheel that consists of two rings with a number of blades attached between them. Air enters one or both ends of the impeller parallel to the shaft and exits one side perpendicular to the shaft. The blades can be straight, slanted in the direction of airflow (forward-curved), or slanted opposite the airflow direction (backward-curved or backward-inclined).

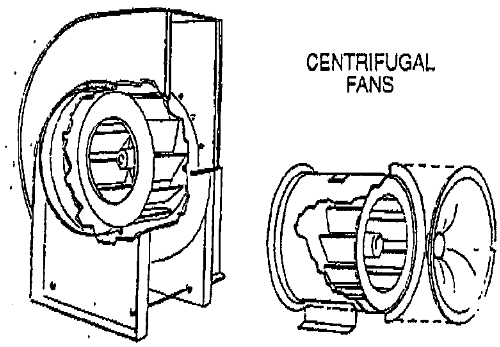
AXIAL-FLOW FANS



Vane-axial Tube-axial Propeller

Figure 3. Types of fans used for ventilating crops.

CENTRIFUGAL FANS



Backward-inclined centrifugal In-line centrifugal

Propeller Fans (panel fans)

These are axial-flow type fans that have from two to about seven long blades attached to a small hub. Fan diameter is usually large relative to the fan's length or thickness. Some propeller fans are called panel fans and are designed for mounting in a wall or plenum divider. Some are belt-driven and some have the impeller hub attached directly to the motor shaft (direct-driven).

Propeller fans normally can't generate more than about 2 in. water pressure. They are most commonly used for potato ventilation, forced-air produce cooling, hay drying, exhausting air from attics or overhead spaces, or general air circulation. They are seldom used for grain drying or aeration.

Tube-axial, vane-axial

These axial-flow fans have a barrel-shaped housing and an impeller that has a large hub with a number of short blades attached to it. They are generally direct-driven and the motor is cooled by the airstream. In positive pressure systems, the air stream captures the waste heat given off by the motor. Vane-axial fans have guide vanes inside the fan housing to help reduce air turbulence.

Tube-axial and vane-axial fans are the most common types used for grain drying and aeration. They are relatively inexpensive and fairly efficient when static pressure is less than about 4 in. water. The main disadvantage of these fans is that they are very noisy.

Centrifugal

The centrifugal fans used for crop drying and storage generally have backward-curved or backward-inclined blades. They are expensive, but are also quiet and are usually the most efficient type of fan when static pressure is greater than about 4 in. water. The motor on centrifugal fans is normally outside the air stream; you need to install a special housing around the motor if you want to capture the heat it gives off.

Forced-air heating and ventilating systems often use centrifugal fans that have forward-curved blades. Motors on these fans can be overloaded and burn out when the fans are operated outside certain pressure ranges. This characteristic makes them unsuitable for many crop drying and storage applications.

In-line centrifugal

These fans have axial airflow, but use a centrifugal-type impeller. Price and operating characteristics are between those of backward-inclined centrifugal and tube-axial fans.

Multiple Fans

It is sometimes necessary or desirable to install more than one fan to provide air to a common plenum or supply manifold for a duct system. Fans can be arranged in parallel or series (Figure 4). Reasons for using multiple fans include:

- Total airflow, pressure, or power requirements exceed the capabilities of the largest fan available from your dealer.
- The starting current for a single large fan motor is greater than the electrical system can handle. The maximum starting current is lower if several small fans are started one at a time.
- When multiple fans are installed, you have the option of turning some of the fans off and operating with a lower airflow when conditions allow.
- Air distribution is sometimes more uniform when several small fans are used in place of one large one.

Parallel

Parallel arrangement means fans are installed side-by-side or at several points along a manifold or plenum. The most common applications are where total airflow requirement is large, but pressure is moderate. When fans are installed in parallel, they all face the same pressure. Total airflow is estimated by adding the airflow provided by each fan at the expected pressure.

Series

Series arrangement, where fans are fastened in line or end-to-end, is not used very often. When it is used, it generally involves tube-axial or vane-axial fans in situations where pressure is relatively high, such as in deep grain bins. Series arrangement is seldom used with centrifugal fans and seldom are more than two axial-flow fans connected in series. When fans are arranged in series, each fan handles the same airflow. Total pressure is estimated by adding the pressure developed by each fan at the expected airflow.

Determining Air Flow Provided by Existing Fans

Knowledge of the airflow that a fan is providing allows you to estimate the time it will take to dry or cool a crop. This in turn, helps you determine whether steps need to be taken to prevent unacceptable quality loss before the task is completed.

The first step in determining airflow is to measure static pressure in the duct or plenum between the fan and the crop (Figure 1). Drill a small hole (1/8 in. should be adequate) in the wall of the duct or plenum and press a tube from one side of a pressure gauge or u-tube manometer against the hole. Then, take the pressure reading and use its absolute value (this means assume the reading is positive even if it's a negative pressure system) to determine the airflow. Use the AMCA performance data for that model fan at that pressure. To get airflow rate (cfm/bu, for example), divide the airflow from the performance table or graph by the amount of crop being served by the fan.

For example, suppose fan #4 from Table 7 is being used to dry 10 tons of hay and the static pressure reading in the duct to which the fan is attached is 1.0 in. water. The fan performance data in Table 7 shows that fan #4 provides 2775 cfm against a pressure of 1 in. Airflow per ton is 2775 cfm ÷ 10 tons = about 278 cfm/ton. This value is within the recommended range for hay drying given in Table 1.

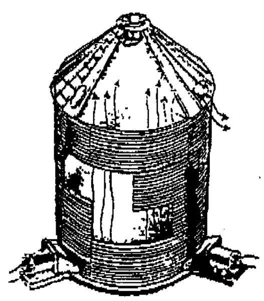
Because airflow resistance and static pressure vary with type of crop, crop depth, amount of fines present, and the way the crop is piled, you need to repeat the above procedure and determine a new airflow anytime conditions change.

Selecting Fans

Calculate total airflow needed

The first step in selecting a fan is to determine the total airflow it must provide. You can use the airflow rates in Table 1 as a guide. Choose an airflow rate, estimate the total quantity of crop to be served by the fan, and then multiply the airflow rate by crop quantity to get total airflow requirement.

PARALLEL



SERIES

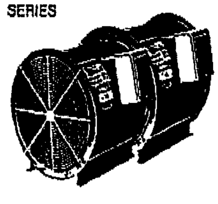


Figure 4. Parallel and series fan arrangement.

For example, if you want to supply 1 cfm/bu to natural-air dry corn in a 27-ft diameter by 16 ft deep bin that has a full perforated floor, calculate airflow as follows:

Bin capacity = (π ÷ 4) x (diameter)^2 x depth x 0.8 bu/cu ft
= 0.785 x 27 ft x 27 ft x 16 ft x 0.8 bu/cu ft
= 7325 bu

Total airflow = 1 cfm/bu x 7325 bu = 7325 cfm

Estimate static pressure

The next step in selecting a fan is to estimate the pressure the fan will be operating against. For grains and oilseeds, use the desired airflow rate and expected crop depth and read the appropriate pressure value from Tables 2 through 6. Remember to add 0.5 in. to the value from the table if air is distributed through a duct system. For hay, potatoes, or other produce, use 1 in. water as a pressure estimate unless a better number is available.

Continuing our example, Table 3 indicates that the expected pressure for 16 ft of corn and an airflow rate of 1 cfm/bu is 2.4 in. water.

Estimating fan power requirements

Fans are usually described by the horsepower (hp) rating of the motor used to drive the impeller. It's helpful when selecting fans to estimate the power requirement first so you know where to start looking in the manufacturer's catalog.

Fan motor size depends on the total airflow being delivered, the pressure developed, and the impeller's efficiency. Impeller efficiencies generally range from 40% to 65%. If we assume an average value of 60%, we can use the following formula to estimate the fan power requirement.

Fan power (hp) = airflow (cfm) x static pressure (in. water) ÷ 3814

In our example,
Fan power = 7325 cfm x 2.4 in. water ÷ 3814 = 4.6 hp.

Selecting the best fan available

Purchase cost and noise during operation can be important factors in selecting a fan, but the most critical factor is whether the fan can provide enough airflow at the expected operating pressure. Start by looking at performance data for a fan having a motor rated just under the power value you calculated. If this fan provides more than enough airflow, look at the next size smaller. If your first pick is too small, try the next size larger.

If we use the list of fans in Table 7 to select a fan for our example problem, we see that fan #7 (a 5.0-hp axial flow fan) comes closest to meeting our needs. Fans #6 and #10 wouldn't provide enough airflow at 2.4 in. water and fans #8 and #11 would provide much more airflow than is needed.

Sometimes fans produced by one manufacturer won't meet your needs and you'll have to look at another manufacturer's fans. Or, if you are having trouble finding a fan that is big enough, you might consider using several smaller fans. (See the section on multiple fans.)

Computerized fan selection

The fan selection procedure that was just described is not too difficult, but there is an easier way to select fans for grain bins.

You can use the FANS or WINFANS (Windows version) computer programs available from the University of Minnesota Biosystems and Agricultural Engineering Department and some county Extension offices. The program is very user friendly and guides you through the fan selection process by asking some simple questions about your grain drying or storage bin. If you have access to the World Wide Web, the program can be downloaded from: www.bae.umn.edu/extens/harvest.html. The program allows you to select fans from a list of over 200 commercially available models and see if the selected models provide the desired airflow.

Summary

Selection of proper fans and determination of actual airflow provided by existing fans are important steps in preserving quality of crops after harvest. Make sure you have fans that provide enough airflow to dry or cool crops before unacceptable quality loss occurs. Contact your local extension office for more information on selecting fans or managing crops after harvest.

Table I. Airflow recommendations for drying, cooling, and storing crops.

Natural-air drying grains & oilseeds	0.75 to 1.5 cfm/bu
Aeration of stored dry grains & oilseeds	0.05 to 0.5 cfm/bu
Hay drying	150 to 600 cfm/ton
Potato ventilation (airflow per hundredweight)	0.5 to 1.5 cfm/cwt
Forced-air produce cooling	1 to 10 cfm/lb

H 000392

Table 2. Airflow resistance data for barley and oats.
Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain Depth (ft)	Airflow (cfm/bu) 0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5
6	0.1	0.1	0.1	0.2	0.4	0.5	0.7	0.8	1.1
8	0.1	0.1	0.2	0.4	0.7	0.9	1.2	1.5	2.1
10	0.1	0.1	0.3	0.7	1.1	1.5	2.0	2.5	3.6
12	0.1	0.2	0.5	1.0	1.6	2.3	3.0	3.7	5.4
14	0.1	0.3	0.7	1.4	2.2	3.2	4.2	5.3	7.8
16	0.2	0.3	0.9	1.9	3.0	4.3	5.7	7.2	10.6
18	0.2	0.4	1.1	2.4	3.9	5.6	7.5	9.5	14.1
20	0.3	0.5	1.4	3.0	4.9	7.1	9.5	12.2	18.1
15	0.4	0.8	2.2	4.9	8.2	11.9	16.1	20.7	31.1
30	0.6	1.2	3.2	7.4	12.4	18.3	24.8	32.1	48.7
40	1.0	2.1	6.0	14.2	24.4	36.2	49.8	*	*
50	1.6	3.4	9.9	23.8	41.4	*	*	*	*

* Static pressure is excessive—greater than 50 in. water.

Table 3. Airflow resistance data for shelled corn.
Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. (If corn is stirred, which tends to decrease airflow resistance, divide table values by 1.5.) Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain Depth (ft)	Airflow (cfm/bu) 0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
6	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.6
8	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.2
10	0.1	0.1	0.2	0.3	0.5	0.8	1.1	1.4	2.0
12	0.1	0.1	0.2	0.5	0.8	1.2	1.6	2.1	3.2
14	0.1	0.1	0.3	0.7	1.2	1.7	2.3	3.0	4.6
16	0.1	0.1	0.4	0.9	1.6	2.4	3.2	4.2	6.4
18	0.1	0.2	0.5	1.2	2.1	3.1	4.3	5.6	8.7
20	0.1	0.2	0.7	1.6	2.7	4.0	5.6	7.3	11.3
25	0.2	0.4	1.1	2.6	4.6	7.0	9.7	12.8	19.9
30	0.3	0.5	1.6	4.1	7.2	11.0	15.3	20.3	31.9
40	0.5	1.0	3.1	8.1	14.6	22.6	31.9	42.5	*
50	0.7	1.6	5.3	14.0	25.6	39.9	*	*	*

*Static pressure is excessive—greater than 50 in. water.

H 000393

Table 4. Airflow resistance data for soybeans and confectionery sunflowers.
Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain Depth (ft)	Airflow (cfm/bu) 0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
6	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5
8	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.9
10	0.1	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.5
12	0.1	0.1	0.2	0.4	0.7	0.9	1.2	1.6	2.3
14	0.1	0.1	0.3	0.6	0.9	1.3	1.7	2.2	3.3
16	0.1	0.1	0.3	0.8	1.2	1.8	2.4	3.0	4.5
18	0.1	0.2	0.4	1.0	1.6	2.3	3.1	4.0	6.0
20	0.1	0.2	0.6	1.2	2.0	3.0	4.0	5.1	7.7
25	0.2	0.3	0.9	2.0	3.4	5.0	6.8	8.8	13.4
30	0.2	0.5	1.3	3.1	5.2	7.7	10.6	13.7	21.0
40	0.4	0.9	2.5	5.9	10.3	15.4	21.4	28.0	43.4
50	0.6	1.4	4.1	10.0	17.6	26.7	37.2	49.1	*

* Static pressure is excessive—greater than 50 in. water.

Table 5. Airflow resistance data for oil-type sunflowers.
Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain Depth (ft)	Airflow (cfm/bu) 0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
6	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.9
8	0.1	0.1	0.1	0.3	0.5	0.7	0.9	1.1	1.7
10	0.1	0.1	0.2	0.5	0.8	1.1	1.5	1.9	2.8
12	0.1	0.1	0.3	0.7	1.2	1.7	2.3	2.9	4.4
14	0.1	0.2	0.5	1.0	1.7	2.4	3.3	4.2	6.4
16	0.1	0.2	0.6	1.4	2.3	3.3	4.5	5.8	8.8
18	0.1	0.3	0.8	1.8	3.0	4.4	6.0	7.8	11.8
20	0.2	0.3	1.0	2.3	3.8	5.6	7.7	10.0	15.3
25	0.3	0.6	1.6	3.7	6.5	9.7	13.3	17.4	26.9
30	0.4	0.8	2.4	5.7	10.0	15.1	20.9	27.5	42.7
40	0.7	1.5	4.5	11.3	20.1	30.7	43.0	*	*
50	1.1	2.4	7.5	19.3	34.8	*	*	*	*

* Static pressure is excessive—greater than 50 in. water.

Table 6. Airflow resistance data for wheat and sorghum.
Values in the table have been multiplied by 1.3 for wheat and 1.5 for sorghum to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain Depth (ft)	Airflow (cfm/bu)								
	0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
4	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.7
6	0.1	0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.7
8	0.1	0.1	0.3	0.7	1.1	1.5	1.9	2.3	3.2
10	0.1	0.2	0.5	1.1	1.7	2.3	3.0	3.7	5.3
12	0.1	0.3	0.8	1.6	2.5	3.4	4.5	5.6	7.9
14	0.2	0.4	1.0	2.2	3.4	4.8	6.3	7.8	11.3
16	0.3	0.5	1.4	2.9	4.6	6.4	8.4	10.6	15.3
18	0.3	0.7	1.7	3.7	5.9	8.3	11.0	13.8	20.0
20	0.4	0.8	2.2	4.7	7.5	10.5	13.9	17.6	25.6
25	0.6	1.3	3.4	7.5	12.2	17.4	23.1	29.4	43.3
30	0.9	1.9	5.1	11.2	18.3	26.3	35.3	45.0	*
40	1.7	3.4	9.3	21.1	35.1	*	*	*	*
50	2.6	5.4	15.0	34.8	*	*	*	*	*

* Static pressure is excessive—greater than 50 in. water.

Table 7. Example of fan performance data.
This data is provided as an illustration only; these fans are not commercially available.

Fan #	Hp	Cubic feet per minute (cfm) at indicated static pressure (inches of water)												
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
Fans 1 through 9 are axial-flow fans														
1	0.33	1,435	620	290										
2	0.5	1,880	960	800	620	380								
3	0.75	1,690	1,460	1,170	780									
4	1.0	2,775	2,500	2,075	1,150	775	500	260						
5	1.5	3,675	3,475	3,275	3,000	2,425	1,700	1,375						
6	3.0	6,400	5,700	5,200	4,500	3,700	2,900	2,200						
7	5.0	9,600	8,550	7,600	6,800	6,150	5,300	4,200	1,550					
8	7.5	13,400	12,500	11,500	10,400	9,000	7,500	6,200	4,450	2,250	1,350	650		
9	10.0	15,700	15,000	14,200	13,400	12,600	11,600	10,500						
Fans 10 through 14 are centrifugal fans														
10	5.0	7,600		6,700		5,800		4,800		3,500		1,500		
11	7.5	9,600		8,900		8,000		7,200		6,100		5,000		
12	10.0	13,450		12,720		11,960		11,120		10,180		9,040		7,450
13	15.0	16,000		15,100		14,200		13,100		11,800		10,000		
14	20.0	21,725		20,430		19,140		17,750		16,140		14,120		11,360

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AAON
Heating & Cooling Products

marketing memo

To: All AAON Sales Representatives

October 1, 2001

NEW PROMOTIONAL LITERATURE

The RL Series
40 to 230 Tons for Air Cooled, Evaporative Cooled or Water Cooled

Enclosed with this memo are 50 copies of the new RL Series full color promotional literature. Read this over completely. Get ready for the two RL product sessions that will be held here in Tulsa this month to answer all your questions.

Notice the photo on page 2 is an air cooled unit being built in the West Tulsa plant. The centerfold of product features also shows those taken of evaporative cooled models, as well as, many of the common features of all the models.

RL Product Hi-Lites
In this session you will see a complete evaporative cooled unit. All of the features will be reviewed in a unique manner that you will be able to "take home with you" in your pocket. You will not forget this presentation.

RL Software
The RL product has many of the features that you always expect from AAON. It also will have new and unrivaled features that you must learn how to select and use to our best advantage. The RL software will be extensively demonstrated in this session. With the RL Series you have fan options that will be presented to you by the software, with the corresponding sound levels.

The Unit Rating sheet gives you all the performance information you need including sound information.

The overall dimensional drawing of the selection will also be an output of the software. No guessing or waiting to get information back from the factory to get the customer the dimensional data they always want immediately.

Get your questions ready - Don't miss any of the RL sessions. We look forward to seeing you at the Sales meeting.

Jim Parro

Jim Parro
Marketing Manager

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		2/5 PER REP(DEBBIE) OK TO SHIP 2/19. JL			
		TAX X 8: SUBJECT TO CHANGE.			
1	2	38221 RL-155-3-0-AB06-000: HGC1E00GB10B0JAAC00H000A000000X	EA	94,890.910	189,781.82
2	1	@FREIGHT	EA	4,600.000	4,600.00
		SUBTOTAL			194,381.82
		TAX (0.000%)			0.00
		DISCOUNT- 20 DAYS PAYMENTS RECEIVED 20 DAYS FROM INVOICE DATE $ 1,897.81			
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		Customer #:	34865 AAON Contact:
Ship To	Weirton Medical Center c/o Scalise Industries 601 Colliers Way Weirton, W.Va. 26062 (Weirton) USA	Shop Order #:	Customer Contact:
		Rep #1:	778 Rep #2:
		Action:	Release To Production
		Ship:	ALLOWED Via: Best Way
		Notify:	Joe Scalise 48 Hours Before Delivery @ Phone No: 1-724-746-4400
		Marketing Code:	Shipping Zone:

Qty	Part #	Description	Unit Net Ea.	Ext. Price
2		RL-166-8-0-AB06-400:HGC1-E00-QH1-0B0-JAAC00H-00-0A000006D	$94,890.91	~~$189,781.83~~
TAG UNIT: RTU# 1,2		CFM: 62000 ESP: 2.5"		

Rep Contact: Creed Hess

Ordered By: Creed Hess

Multiplier: 0.816		Total List Price $:	~~$003,482.00~~
		Total Net (Rep. Cost) $:	$189,781.80
		Freight $:	$400.00
		Commission $:	$0.00
		Total Billing* $:	$189,781.80

197,981

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RL-155-3-0-AB06-000:HGC1-E00-QB1-0B0-JAAC00H-00-0A000000B

Tag: RTU# 1,2

Job Name:	*Weirton Medical Center*	Worksheet For:	*Tobey-Karg Sales Agency*
Job Number:	*Job #1*	Worksheet Date:	*November 19, 2001*

	Base Option	Description	List Price	Rep. Price	Cust. Price
R	Series	Roof Top Unit			
L	Generation	Eighth Generation			
155	Size	One Hundred and Fifty Five			
3	Voltage	460V/3Ø/60Hz	$0.00	$0.00	$0.00
0	Interior Protection	Standard	$0.00	$0.00	$0.00
A	Cooling Style	Draw Thru–R22 Dual Circuited Compressors	$5464.00	$1721.16	$1721.16
B	Cooling Configuration	Air Cooled Cond w/ 6R coil High CFM	$151733.00	$47795.89	$47795.89
0	Cooling Coating	Std	$0.00	$0.00	$0.00
6	Cooling Stages	6 Stage	$1880.00	$629.20	$629.20
0	Heating Type	No Heat	$0.00	$0.00	$0.00
0	Heating Designation	No Heat	$0.00	$0.00	$0.00
0	Heating Stages	No Heat	$0.00	$0.00	$0.00

	Feature Option	Description	List Price	Rep. Price	Cust. Price
H	1A. Outside Air Options	Heat Wheel Small (S) (2-74 inch wheel)	$37851.00	$11948.95	$11948.95
G	1B. RA Blower Configuration	2 Blowers (Prem eff mtrs) 2-motors 2-VFD	$12467.00	$3927.10	$3927.10
C	1C. RA Blower	Blower C (42" Dia 12 Blade)	$3524.00	$1110.06	$1110.06
1	1D. RA Motor	25.0 hp (1760 rpm)	$6324.00	$1992.06	$1992.06
E	2. Outside Air Controls	DDC Econ Control	$4886.00	$1539.09	$1539.09
0	3. Discharge Location	Bottom Discharge	$0.00	$0.00	$0.00
0	4. Return Location	Bottom Return	$0.00	$0.00	$0.00
Q	5A. SA Blower Configuration	4 Blowers w/(Prem eff mtr) w/4-VFD's	$25115.00	$7911.22	$7911.22
B	5B. SA Blower	Blower B (30" Diameter)	$7904.00	$2489.76	$2489.76
1	5C. SA Motor	25.0 hp (1760 rpm)	$12648.00	$3984.12	$3984.12
0	6A. Pre-Filter	2" Pleated	$0.00	$0.00	$0.00
B	6B. Final Filter	12" Cartridge 85% Eff-Filter Box B	$15730.00	$4954.95	$4954.95
0	6C. Filter Options	Std	$0.00	$0.00	$0.00
J	7. Refrigeration Controls	6 MTDR On & Off + 20 STDR + 115V Outlet Factory	$1405.00	$442.57	$442.57
A	8. Refrigeration Options	Hot Gas Bypass Lead Stage [HGB]	$4870.00	$1376.55	$1376.55
A	9. Refrigeration Accessories	Sight Glass	$1700.00	$535.50	$535.50
C	10. Power Options	600 Amps Power Switch	$3770.00	$1187.55	$1187.55
0	11. Safety options	Std	$0.00	$0.00	$0.00
0	12. Controls	Std	$0.00	$0.00	$0.00
H	13. Special Controls	Field Installed DDC Controls by Others	$0.00	$0.00	$0.00
0	14A. Pre-Heat Configuration	Std (No Preheat)	$0.00	$0.00	$0.00
0	14B. Pre-Heat Sizing	Std (No Preheat)	$0.00	$0.00	$0.00
0	15. Option Boxes	Std	$0.00	$0.00	$0.00
A	16. Cabinet Options	Stainless Steel Drain Pans	$4590.00	$1445.85	$1445.85
0	17. Cabinet Options	Std	$0.00	$0.00	$0.00
0	18. Customer Code	Std	$0.00	$0.00	$0.00
0	19. Code Options	Std ETL USA Listing	$0.00	$0.00	$0.00
0	20. Unit Splits	Std (One Piece Unit)	$0.00	$0.00	$0.00
0	21. Evap & Water Condenser	Std (No Evap or Water Condenser)	$0.00	$0.00	$0.00
0	22. Blank	Std	$0.00	$0.00	$0.00
B	23. Type	Std (Includes Gray Paint)	$0.00	$0.00	$0.00
		Subtotal	$301,241.00	$94,890.91	$94,890.91
		Quantity	2		
		Total	$602,482.00	$189,781.83	$189,781.83

11/19/01 16:01 FAX 412 391 8816 TOBEY KARG SALES & SERV. → AAON 002/006

AAON, Inc. A-0440 **Submittal**

2425 South Yukon Ave - Tulsa, Oklahoma 74107-2728 - Ph. (918) 583-2266 Fax (918) 583-6094

AAONEcat32 Ver. 4.00 Beta

RL-155-3-0-AB06-000:HGC1-E00-QB1-0B0-JAAC00H-00-0A000000B

Tag: RTU#1,2

Job Name: Weirton Medical Center
Job Number: Job #1
Submittal For: Tobey-Karg Sales Agency
Submittal Date: November 19, 2001

	Base Option	Description
R	Series	Roof Top Unit
L	Generation	Eighth Generation
155	Size	One Hundred and Fifty Five
3	Voltage	460V/3Ø/60Hz
0	Interior Protection	Standard
A	Cooling Style	Draw Thru-R22 Dual Circuited Compressors
B	Cooling Configuration	Air Cooled Cond w/ 6R coil High CFM
0	Cooling Coating	Std
6	Cooling Stages	6 Stage
0	Heating Type	No Heat
0	Heating Designation	No Heat
0	Heating Stages	No Heat

	Feature Option	Description
H	1A. Outside Air Options	Heat Wheel Small (S) (1-74 Inch wheel)[1]
G	1B. RA Blower Configuration	3 Blowers (Pairs of mtr) w/ 2-motors 2-VFD
C	1C. RA Blower	Blower C (42" Dia 12 Blade)
I	1D. RA Motor	25.0 hp (1760 rpm)
E	2. Outside Air Controls	DDC Econ Control
0	3. Discharge Location	Bottom Discharge
0	4. Return Location	Bottom Return
Q	5A. SA Blower Configuration	4 Blowers w/(Prs) of mtr w/4-VFD's
B	5B. SA Blower	Blower B (30" Diameter)
1	5C. SA Motor	35.0 hp (1760 rpm)
0	6A. Pre-Filter	2" Pleated
B	6B. Final Filter	12" Cartridge 85% RF-Filter Box B
0	6C. Filter Options	Std
J	7. Refrigeration Controls	5 MTDR On & Off + 20 STDR + 115V Outlet Factory Wired
A	8. Refrigeration Options	Hot Gas Bypass Lead Stage (HGB)
A	9. Refrigeration Accessories	Sight Glass
C	10. Power Options	500 Amps Power Switch
0	11. Safety options	Std
0	12. Controls	Std
H	13. Special Controls	Field Installed DDC Controls by Others
0	14A. Pre-Heat Configuration	Std (No Preheat)
0	14B. Pre-Heat Sizing	Std (No Preheat)
0	15. Option Boxes	Std
A	16. Cabinet Options	Stainless Steel Drain Pans
0	17. Cabinet Options	Std
0	18. Customer Code	Std
0	19. Code Options	Std ETL USA Listing
0	20. Unit Splits	Std (One Piece Unit)
0	21. Evap & Water Condenser	Std (No Evap or Water Condenser)
0	22. Blank	Std
B	23. Type	Std (Includes Gray Paint)

AAON, Inc. A-0440 **Unit Rating**

2425 South Yukon Ave - Tulsa, Oklahoma 74107-2728 - Ph. (918) [illegible] Fax (918) [illegible]

AAONEcat32 Ver. 4.00 Beta

RL-155-3-0-AB06-000:HGC1-E00-QB1-0B0-JAAC00H-00-0A000000B

Tag: RTU# 1,2

Job Information

Job Name:	*Weirton Medical Center*
Job Number:	*Job #1*
Site Altitude:	*0 ft*

Unit Information

Unit Size:	*One forty five tons*
Cabinet Size:	*D*
Approx. Op./Ship Weights:	*31356 / 31184 lbs.*
Supply CFM/ESP:	*62000 / 2.5 in. wg.*
Exhaust CFM/ESP/TSP:	*41000 / 1.30 / 2.73 in. wg.*
Outside CFM:	*11500*
Ambient Temperature:	*92 °F DB / 75 °F WB*

Static Pressure

External:	*2.50 in. wg.*	Economizer:	*0.21 in. wg.*
Evaporator:	*0.94 in. wg.*	Heating:	*0.00 in. wg.*
Filters Clean:	*0.68 in. wg.*	Cabinet:	*0.59 in. wg.*
Dirt Allowance	*0.35 in. wg.*	Heatwheel:	*1.80 in. wg.*
		Total:	*6.57 in. wg.*

Cooling Section

	Gross	Net
Total Capacity:	*1585.76*	*1369.62 MBH*
Sensible Capacity:	*1209.04*	*992.00 MBH*
Latent Capacity:	*376.72 MBH*	
EW Total Cooling Capacity:	*6.87 °F MBH*	
Mixed Air Temp:	*75.00 °F DB*	*64.00 °F WB*
Entering Air Temp:	*75.00 °F DB*	*64.00 °F WB*
Lv Air Temp (Coil):	*53.71 °F DB*	*53.64 °F WB*
Lv Air Temp (Unit)	*57.54 °F DB*	*55.20 °F WB*
Supply Air Fan:	*DT - 4 x 300 @ 19.98 BHP Ea.*	
SA Fan RPM / Width:	*1580 / 99%*	
Exhaust Air Fan:	*2 x MW4212-35 @ 19.19 BHP Ea.*	
EA Fan RPM:	*1500*	
Evaporator Coil:	*86.8 ft² / 6 Rows / 12 FPI*	
Evaporator Face Velocity:	*599.0 fpm*	
Energy Recovery Wheel:	*1 x ERC-7490*	

Heating Section

PreHeat Type:	*Std (No Preheat)*
Heating Type:	*No Heat*

EER - ARI Listing Information

No ARI Rating Program Exists for Units Over 250 MBH
All AAON Units Are Tested in Accordance With ARI Standards

EER @ ARI Conditions:	*9.2*	EER Compressor Only @ ARI Conditions:	*12.0*
Application EER @ Op. Conditions:	*5.8*	Condensing Unit EER @ Op. Conditions:	*11.1*

Electrical Data

Rating:	*460/3/60*	Minimum Circuit Amp:	*492*
Unit FLA:	*481*	Maximum Overcurrent:	*500*

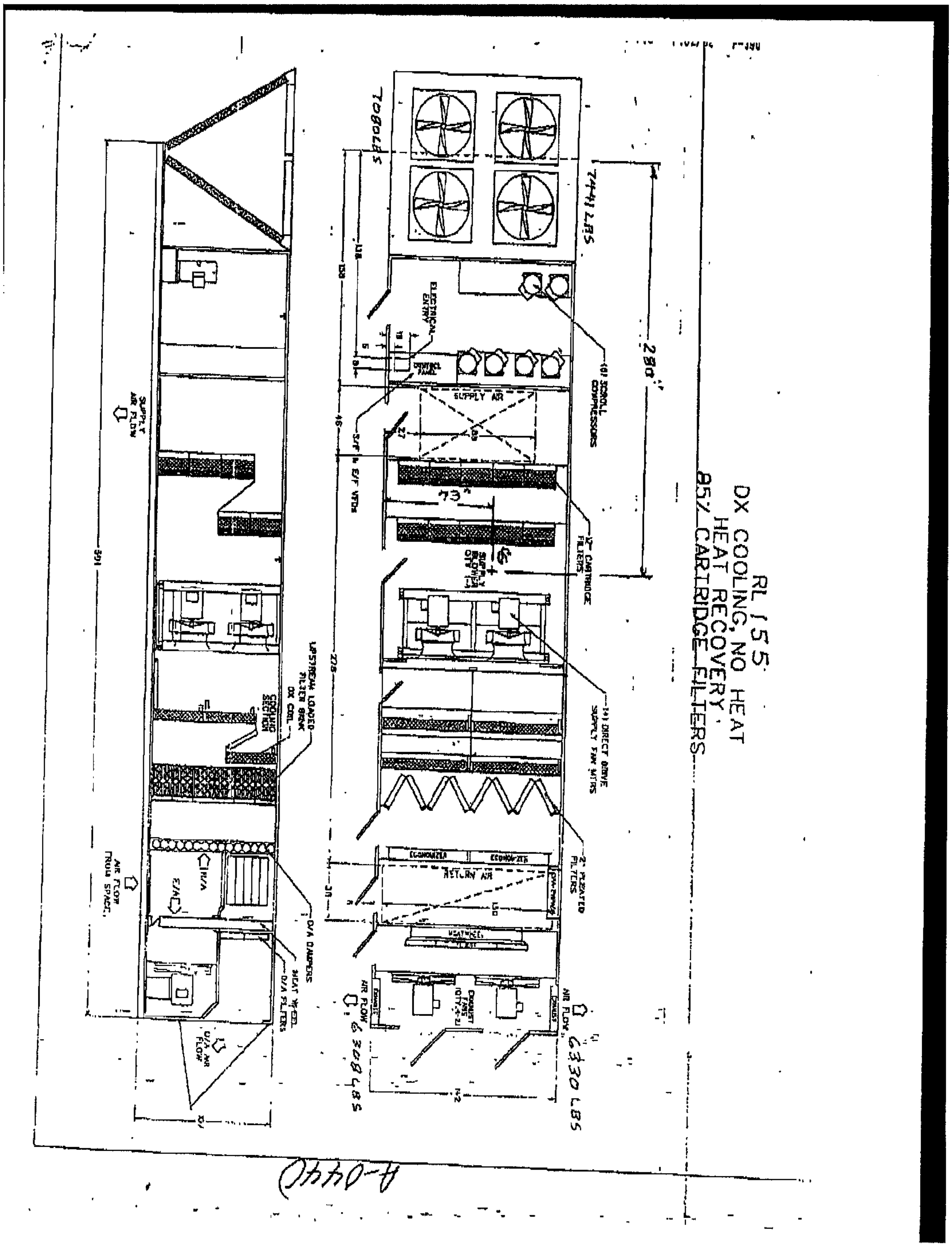
Motors

	Qty	HP	VAC	Phase	RPM	FLA	RLA
Compressor 1:	2		460	3			28.96
Compressor 2:	4		460	3			46.15
Condenser Fans:	5	5.00	460	3	1170	7.3	
Supply Fan:	4	25.00	460	3	1760	34.0	
Exhaust Fan:	2	25.00	460	3	1760	34.0	
Heatwheel:	1	0.25	230	1	1760	0.0	

Cabinet Sound Power Levels[1]

Octave Bands:	63	125	250	500	1000	2000	4000	8000
Discharge LW(dB):	100	99	99	101	99	9?	92	85
Return LW(dB):	96	91	85	77	87	6?	72	74

[1] *Sound power levels are given for informational purposes only. The sound levels are not guaranteed.*


RL 155
DX COOLING, NO HEAT
HEAT RECOVERY
85% CARTRIDGE FILTERS
7441 LBS
7080 LBS
280"
6330 LBS
6308 LBS
SUPPLY AIR
RETURN AIR
ECONOMIZER
2" PLEATED FILTERS
(4) SCROLL COMPRESSORS
ELECTRICAL ENTRY
UPSTREAM LOADED FILTER BANK DX COIL
O/A DAMPERS
HEAT WHEEL
O/A FILTERS
SUPPLY AIR FLOW
AIR FLOW FROM SPACE
O/A AIR FLOW
A-0440

AAON®
Heating & Cooling Products

REDEMPTION COUPON

Nº: 778-2306

.315

SPECIAL MULTIPLIER DISCOUNT

FOR

RL ROOFTOP UNITS

Issued To: **Rich Nalevanko**

Tobey-Karg Sales Agency
Pittsburgh, PA

Job Name: WEIRTON MEDICAL

Signature: [signature] Date: 11 / 16 / 01

Coupon Expires: December 31, 2002

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SOI Tracking Form

Sales

MUST BE COMPLETE BY: 11/9/01

SOLD TO: YORK/KAAG

JOB NAME:

AAON CONTACT:

REQUESTED SHIP DATE: 7/11/02 (4)

DSO NUMBER:

PROJECTED SHIP DATE: 11/19/01

COMMENTS:

Engineering

MUST BE COMPLETE BY:

SOI REQUIRED ?: ☐ YES ☐ NO

WIRING DIAGRAMS COMPLETE ?: ☐ YES ☐ NO

AEN / ECN No.: ☐ N/A

SPECIAL NAMEPLATE INFORMATION: ☐ YES ☐ NO

BILL WORK REQ. ON STD. BILLS ?: ☐ YES ☐ NO

SPECIAL ORDER PARTS REQ. ?: ☐ YES ☐ NO

ALL UNITS CONFIGURED ?: ☐ YES ☐ NO

AGENCY APPROVED ?: ☐ YES ☐ NO

IF NO AGENCY APPROVAL, EXPLAIN:

COMMENTS:

PREPARED BY:

DATE GIVEN TO PROD. / INV. CNTL.:

Production / Inventory Control

MUST BE COMPLETE BY:

SPECIAL PARTS ON ORDER ?: ☐ YES ☐ NO

SOI INFO. CORRECT TO ENTER ?: ☐ YES ☐ NO

SPECIAL BILL WORK COMPLETE ?: ☐ YES ☐ NO

COST ROLL-UP COMPLETE ?: ☐ YES ☐ NO

ALL WORK ORDERS ENTERED ?: ☐ YES ☐ NO

DATE GIVEN TO MANUFACTURING?:

PREPARED BY:

DATE GIVEN TO SALES

Manufacturing

MUST BE COMPLETE BY:

SOI COMPLETE ?: ☐ YES ☐ NO

WIRING DIAGRAM COMPLETE ?: ☐ YES ☐ NO

NAMEPLATE INFO COMPLETE ?: ☐ YES ☐ NO

SPECIAL INSTRUCTIONS COMPLETE ?: ☐ YES ☐ NO

COMMENTS:

PREPARED BY:

DATE GIVEN TO PROD. / INV. CNTL.:

SPECIAL COMMENTS:

7-11-95

AAON, Inc. Memorandum via Datafax

To: Creed Hess
Tobey Karg

From: Jim Parro J.P.

Date: November 19, 2001

Subject: RL Selection for Weirton Medical Center

cc: B. Pohl, D. Schwartz, M. Roark, R. Schoonover, S. Hammoud, B. Smith, D. Knebel

Confirming our telephone conversation today, I review the following.

We have received and will be entering the subject order for 2 of the RL-155s. As I mentioned to you, we will be adding the net freight amount to the order of $4608.

Program Error to be Corrected
While you were using the new program, you were able to key the state name directly as "W. Va." rather than using the dropdown box to point and click on "WV".

This disabled the automatic calculation of the freight amount and your printout that was sent to us indicated Zero $ for freight.

ch111901.doc

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Sunon Group, Taiwan

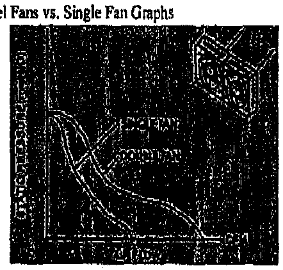
Technology

The Parallel and Series Operation

BACK

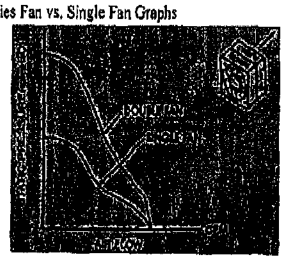
The parallel operation is defined as using two or more fans side by side.

The Operation of Parallel Fans vs. Single Fan Graphs



¡@¡@The volume air flow of two fans in parallel will be double in the free-air condition only. If the parallel fans are applied to the higher system resistance situation, the high system resistance that enclosure has, the less increase in flow results with parallel fan operation. Thus, this type of application is only recommended for the low system resistance situation -- when the fans can operate near free delivery.

The Performance of Series Fan vs. Single Fan Graphs



The series operation is defined as using two or more fans in series.

The static pressure capacity of two fans in series can be doubled at zero air flow condition, but do not increase the airflow in the free-air situation. An additional fan in series increases the volume flow in a higher static pressure enclosure. Thus, in series operation, the best results are achieved in systems with high resistance.

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Current Article: Series and parallel fans.

Series and parallel fans.

Machine Design; January 26, 1995;

Machine Design

January 26, 1995

Using two or more fans in series or parallel may be a better alternative than a larger fan. First of all, two identical fans are usually less noisy than a single larger unit. Secondly, depending upon arrangement, either static pressure or airflow may be increased while keeping the other parameter near constant. When two fans work side by side, for example, airflow should double at free delivery. However, the higher the system impedance to flow, the lower the flow increase from the second fan. Hence, a parallel arrangement is recommended when the fans operate in low impedance near free delivery. When one fan pushes air into an enclosure and another pulls air out, the fans are in series. Best results from using fans in series are in systems with high impedance. In both series and parallel operation, especially with more than three fans, some areas of the combined performance curve are unstable and should be avoided. However, the instability is unpredictable because it res...

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ebmpapst

Using fans in series and parallel: performance guidelines

Ian McLeod, Engineering Director, Papst plc

When a single fan within a system cannot deliver sufficient airflow to provide the required level of cooling, and the physical size of the enclosure precludes the use of a larger fan, the concept of mounting fans in series or parallel is sometimes considered. In practice however, the only circumstances in which two fans of equal size can provide double the airflow is when they are operating in free air, i.e. no back pressure to restrict the airflow. This is a theoretical situation not found in practice.

The following article examines what really happens and how the performance of multiple fan solutions can be optimised.

Before examining the performance of series and parallel fan arrangements, it is worth considering the basic concepts of airflow characteristics in practical applications.

Fans are used to produce turbulent air currents which when forced through equipment enclosures, collect and remove heat from the internal components. Physical obstructions to this airflow not only provide a reverse pressure, which the fan must overcome, but can also mask components from the cooling air stream. The enclosure designer must therefore consider the cooling paths when the layout is being decided.

Densely packed enclosures exhibit airflow resistance, manifested as pressure loss in the direction of airflow. It's analogous to an electrical generator forcing current through a resistor - the resistor restricts the current flow.

In theory, weighting factors can be applied to determine the flow/pressure characteristics of systems. In practice, the variety of designs used in enclosures and the presence of internal cards, disk drives, power supplies or other elements that interfere with airflow, mean that it is impossible to calculate weighting factors using general formulae. Designers must rely on measurements or rough approximations.

For practical purposes, the pressure loss of an enclosure, Δp, is approximated by the formula:

Δp = Rv x Q/2 x V2

where Rv is a weighting factor for pressure loss in dimensions of m-4 , Q is the density of the displacement medium and V is the velocity of air flow through the system. It can be seen that pressure loss increases as the square of flow rate.

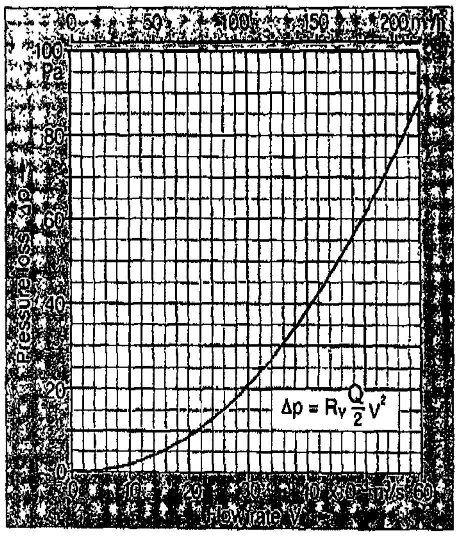
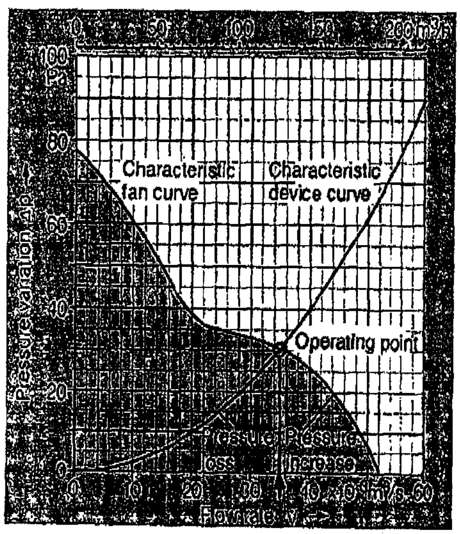


Figure 1 (above) shows the characteristic curve based on this formula where pressure loss is plotted as a function of flow rate. It describes the air flow characteristics of a given enclosure or other system.

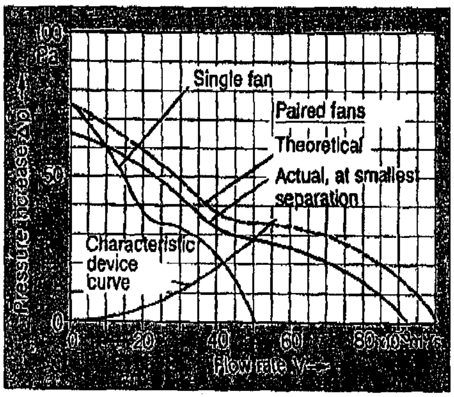


Fans operating in free air generate the maximum possible flow rates, but when fitted within an enclosure the fan is required to overcome the inherent airflow resistance. In order to achieve this the fan needs to produce a pressure increase which will in turn decrease the flow rate. A characteristic fan curve, as shown in **Figure 2** (above),

expresses the relationship between flow rate and pressure.

For a given enclosure and fan, the operating point of the fan is determined by the point at which the characteristic enclosure curve and characteristic fan curve intersect. At this point, the pressure loss of the enclosure is just compensated by the pressure increase of the fan and this point determines the flow rate that is available within that enclosure.

With parallel - side by side - mounting, the flow rate is multiplied by the number of fans but the results must be plotted over the entire characteristic fan curve. If fans are placed too close together, other interference effects come into play and reduce the overall flow. This is largely because the flow of air into a fan is usually laminar and smooth, while the exhausted air is much more turbulent. Even in an ideal environment, where interference effects could be ignored, a pressure increase of four times would be needed to produce a doubling of air flow, as pressure loss increases with the square of flow rate. These differences and the effect of using fans in parallel are shown in **Figure 3** (below). Here, the airflow only increases by approximately 20 to 25% over that achieved with a single fan.



When fans are mounted in series - one in front of the other - the pressure increase, in theory, is doubled. However, if the fans are close together, results will again fall short of the theoretical performance due to the angular component of airflow introduced in the exhaust of the rear fan. This limits the suction effectiveness of the front fan. One solution is to direct the angular component back into the main air current using guide vanes, but this is a rather inelegant and space-hungry solution. A more commonly adopted and balanced approach is to use one fan on the intake and one on the exhaust side of the enclosure or cabinet. The presence of internal components and the large cross-sectional area between the individual fans will mean that airflow is essentially unidirectional. This provides effective airflow and relatively low noise levels.

The choice of series or parallel fan combinations will clearly depend on the individual application. Some solutions may even require a combination of both techniques. They key point to remember is that two fans never mean twice the air flow.

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SP10 3RT

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Fax: 01264 332182
Email: A&Dsales@uk.ebmpapst.com

CLEANPAK INTERNATIONAL Technical Bulletin CLEANPAK M/R/PF Multi/Redundant/Plenum Fan

The application of multiple fans in a common system, in part, provided the impetus of the design of the "plug" fan years ago. CLEANPAK International has incorporated multiple fans in common cabinets for several years to provide systems that require redundancy, to meet architectural profile requirements, and for space savings. The arrangements may be vertical up or down flow or horizontal. The notes below apply generally, but often relate to redundancy issues, which is a benefit of multiple fan operation whether a design requirement or not.

General

There are three general arrangements for multiple plenum fan configurations as noted below. Each arrangement has its benefits.

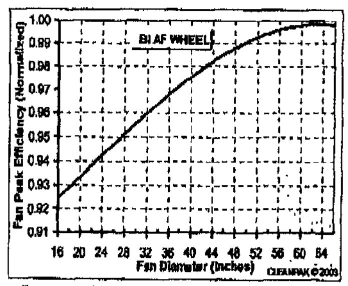
1+1: 2 fans can be provided in a cabinet with either fan capable of supplying 100% of the design flow requirement. This would provide 100% redundancy. Normal operation can be simultaneous or independent.

Twin: 2 fans can be provided in a cabinet with both fans required for the design flow. This arrangement provides capacity in excess of 50% if a single fan fails, since the system pressure drop falls by the square root of the volume decrease. Additional capacity can be provided by ramping the VFD up to the limit of the motor full load amps. Normal operation is always simultaneous.

Xn+1: This system provides a measure of redundancy by providing a number of fans smaller than that required by the 1+1 arrangement. The failure of a single fan is accommodated by the initiation of an unused fan, or the ramp up of all remaining fans. The number of fans can be as high as 12-18, although it is not limited. Normal operation is always simultaneous.

Airflow Isolation

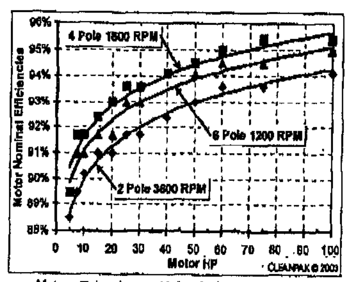
- Inlet or discharge isolation dampers with a solid dividing wall can be provided for fan service of an inoperative fan while operating at design flow for the 1+1 system. The damper pressure drop should be included in the calculation of the total static pressure (TSP).
- An Econo-Disk® may be provided for manual or automatic fan isolation for any of the applications, although as the fans become smaller (18" and under) performance penalties may result. Econo-Disk shutoff characteristics are excellent.
- Inlet isolation dampers can be provided and function similar to, but not as efficiently as, the Econo-Disk. Back draft dampers (heavy duty) can be used but may provide unstable operation at low flows. The damper pressure drop should be included in TSP calculations.
- If some sort of fan isolation is not provided, system performance will suffer a dramatic decrease with a fan failure, due to back flow through the failed fan.



Fan efficiencies are generally higher for larger size fans

Efficiency

- Larger diameter fans have significantly higher peak efficiencies then smaller diameter fans. Selecting fans at optimum efficiency for an operating point requires the ability to vary wheel width and operating speed.
- Larger motors are significantly more efficient than smaller motors.
- Motors operated at 75% full load are slightly more efficient than those that operate at 100% full load.



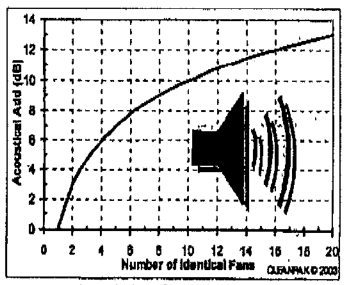
Motor efficiencies are higher for larger size motors

CLEANPAK INTERNATIONAL **Technical Bulletin CLEANPAK M/R/PF**
Multi/Redundant/Plenum Fan

- System efficiency can be improved with internal and external pressure loss reductions such as low velocity coils and high capacity filters.

Dimensions
- For 1+1 systems, inlet and discharge plenum lengths may depend on the normal operating condition. Multiple fan configurations allow for more even velocity profiles for any given length than a single fan configuration.
- Larger fans take more airway length than smaller fans. Service access behind fans is similar for both large and small fans.
- Isolation dampers on the fan inlet increase the airway length.
- Isolation dampers on the fan outlet increase the airway length.
- Large numbers of fans operating as in Xn+1 can reduce the airway length compared to the 1+1 arrangement, particularly if the 1+1 design has an independent operating design rather than a simultaneous operating design.
- Unusual profiles may be accommodated with larger numbers of fans (Xn+1).

Pressure/Volume Control
- VFDs work well when the system follows the fan laws but do not work well if volume varies but the ESP is high and constant, or the fans operate with multiple volumes and constant pressure.
- The Econo-Disk can be used to provide volume control while maintaining design pressure with the simultaneous operation described in 1+1.
- Econo-Disks can be used for both volume and pressure control with manual, pneumatic, or electric actuation.
- Econo-Disks can be used with VFDs for increased flexibility and efficiency.
- Multiple fans such as Xn+1 can be staged and manipulated with VFDs and isolation dampers to offer constant pressure with variable volume.
- Multiple, simultaneous operating fans are generally operated at the same speed.
- Inlet isolation dampers can be used for volume control by "riding the curve" although this is not recommended since it is an inefficient method and may result in unstable operation.



Acoustical add for multiple sources

Sound
- Manufacturers' bare fan sound levels should be adjusted for multiple fan operation. Sound power levels are 11dB higher for 12 fans operating than for only one of the twelve.
- Smaller fans operate at higher speeds than larger fans for any given pressure. This shifts the primary tone of the fan (or blade passage frequency) to higher frequencies and may shift it to a higher octave band. Generally speaking this is advantageous in that higher frequencies are typically attenuated more easily.
- There is a potential for acoustical beats to arise with multiple fan systems.

Vibration Isolation
- 1+1 and twin fan operations are usually internally spring isolated.
- Xn+1 systems with stacked fans, racked, are usually provided without internal isolation, but can be internally spring isolated.

Service
- Smaller fans and motors are easier to physically manipulate than large fans and motors.

CLEANPAK INTERNATIONAL **Technical Bulletin CLEANPAK M/R/PF Multi/Redundant/Plenum Fan**

- Larger numbers of fans, motors, VFDs, dampers, and damper actuators increase service requirements and increase the potential points of failure.
- Generally a fan will be isolated until a system shutdown for major service, or if the fans are screened service is performed while one or more fans are operating.
- Service in an active air stream, without pressure and flow interference can be performed most easily with an airlock.
- Taperlock fan hubs offer quicker and simpler motor/fan wheel replacements than straight bore hubs.
- Bearing life is unaffected by the number of fans operating (1+1 or Xn+1), as the fewer fans use larger motors and bearings and operate at slower speeds.
- Aluminum wheels reduce the bearing load.
- Spare parts are less costly for small fans compared to larger fans.

Electrical
- 100% redundancy systems (1+1) require greater electrical service requirements than other systems but are as efficient or more efficient during operation.
- If single VFDs are used to run multiple motors, each motor requires separate overload protection. VFD to motor lead length is the sum of all the lead lengths fed by a single VFD.
- Multiple VFDs reduce the need for VFD bypass options.

Initial Cost
- $/CFM are lower for larger fans.
- $/HP are lower for larger motors and VFDs.
- Cabinet costs may be reduced with Xn+1 systems, due to the reduced cabinet length.

In the application of multiple smaller fans, one should consider several factors that affect initial cost, operating efficiency, redundancy, and reliability. The discussion above should help the designer evaluate the various options. Optimizing for single or multiple fan applications calls for flexibility from the air handling unit manufacturer. Please contact CLEANPAK's technical staff for further information and assistance with your application.

READ AND SAVE THESE INSTRUCTIONS

PN 463687

GREENHECK

P.O. BOX 410 SCHOFIELD, WISCONSIN 54476-0410
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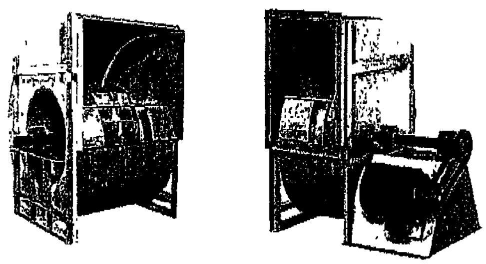
www.greenheck.com

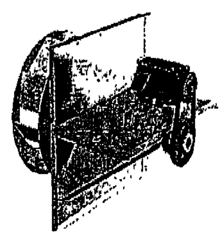
BELT DRIVE

- CENTRIFUGAL (BISW, AFSW, BIDW, AFDW)
- INDUSTRIAL PROCESS (IPA, IPO, IPW)
- PLENUM (QEP)
- PLUG (PLG)

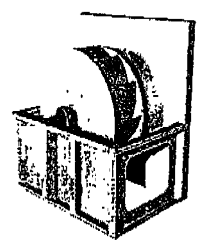
Installation Operating and Maintenance Manual



CENTRIFUGAL AND INDUSTRIAL



PLUG



PLENUM

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Report any damaged equipment to the shipper immediately!

All Centrifugal, Industrial Process, Plenum and Plug Fans are shipped on a skid or packaged to minimize damage during shipment. The transporting carrier has the responsibility for delivering all items in their original condition as received from Greenheck. The individual receiving the equipment is responsible for inspecting the unit for obvious or hidden damage, recording any damage on the bill of lading before acceptance and filing a claim (if required) with the final carrier.

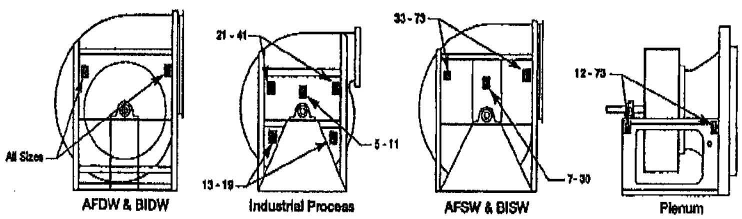
GENERAL INFORMATION

To insure a successful installation, the instructions in this manual should be read and adhered to. Failure to comply with proper installation procedures may void the warranty.

HANDLING

Fans are to be rigged and moved by the lifting brackets provided or by the skid when a forklift is used. See figures below for proper lifting locations. Location of brackets varies by model and size. QEP plenum fans utilize holes located in the framework of the fan. Handle in such a manor as to keep from scratching or chipping the coating. Damaged finish may reduce ability of fan to resist corrosion.

FANS SHOULD NEVER BE LIFTED BY THE SHAFT, HOUSING, MOTOR, BELT GUARD OR ACCESSORIES.



STORAGE

When a fan is not going to be in service for an extended amount of time, certain procedures should be followed to keep the fan in proper operating condition.

- Rotate fan wheel monthly and purge bearings once every three months
- Cover unit with tarp to protect from dirt and moisture (Note: do not use a black tarp as this will promote condensation)
- Energize fan motor once every three months
- Store belts flat to keep them from warping and stretching
- Store unit in location which does not have vibration
- After storage period, purge grease before putting fan into service

If storage of fan is in a humid, dusty or corrosive atmosphere, rotate the fan and purge the bearings once a month. Improper storage which results in damage to the fan will void the warranty.

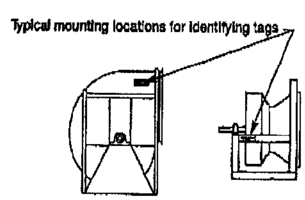
UNIT IDENTIFICATION

The tag below is an example of an identification label on the fan. The information provides general details about the fan, as well as containing specific information unique to the unit. When contacting your Greenheck representative with future needs or questions, please have the information on this label available.

GREENHECK

MODEL
S/N
MARK

Tags are mounted in an area which is clearly visible, usually near the fan outlet on the drive side of the fan. The exact tag location may differ due fan model and size.



Model - General description of fan

S/N - Serial Number assigned by Greenheck, which is a unique identifier for every unit

Mark - Customer supplied identification

CAUTION!

When installing a fan, ensure the proper protective devices are used to protect personnel from moving parts and other hazards. A complete line of protective accessories are available from Greenheck including: inlet guards, outlet guards, belt guards, shaft guards, protective cages and electrical disconnects.

Check local codes to ensure compliance for all protective devices.

For further details on safety practices involving industrial and commercial fans please refer to AMCA Publication 410.

ELECTRICAL DISCONNECTS
All fan motors should have disconnects located in close visual proximity to turn off electrical service. Service disconnects shall be locked out when maintenance is being performed.

MOVING PARTS
All moving parts must have guards to protect personnel. Refer to local codes for requirements as to the number, type and design. Fully secure fan wheel before performing any maintenance. The fan wheel may start "free wheeling" even if all electrical power has been disconnected. Before the initial start-up or any restart, check the following items to make sure that they are installed and secure.

GUARDS (BELT, SHAFT, INLET, OUTLET)
Do not operate fans without proper protective devices in place. Failure to do so may result in serious bodily injury and property damage.

ACCESS DOORS
Before opening access doors ensure the fan wheel has stopped moving and that the wheel has been secured from being able to rotate. Do not operate fan without access door in its fully closed position.

AIR PRESSURE AND SUCTION
In addition to the usual hazards associated with rotating machinery, fans also create a dangerous suction at the inlet. Special caution needs to be used when moving around a fan whether it is in operation or not. Before start-up, make sure the inlet area is clear of personnel and loose objects.

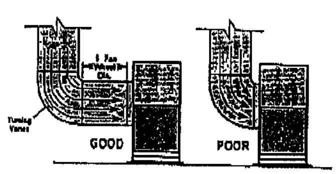
INSTALLATION

Installations with inlet or discharge configurations that deviate from this standard may result in reduced fan performance. Restricted or unstable flow at the fan inlet can cause pre-rotation of incoming air or uneven loading of the fan wheel yielding large system losses and increased sound levels. Free discharge or turbulent flow in the discharge ductwork will also result in system effect losses. Refer to the following diagrams for the most efficient installation conditions.

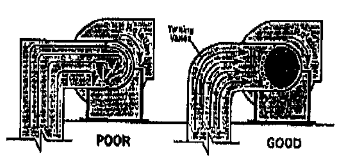
CENTRIFUGAL AND INDUSTRIAL PROCESS FANS - INSTALLATIONS

DUCTED INLET INSTALLATIONS

Inlet Duct Turns
Installation of a duct turn or elbow too close to the fan inlet reduces fan performance because air is loaded unevenly into the fan wheel. To achieve full fan performance, there should be at least one fan wheel diameter between the turn or elbow and the fan inlet.



Inlet Spin
Inlet spin is a frequent cause of reduced fan performance. The change in fan performance is a function of the intensity of spin and not easily defined. The best solution is proper duct design and airflow patterns.



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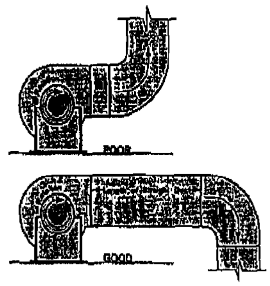
DUCTED OUTLET INSTALLATIONS

Discharge Duct Turns

Duct turns located near the fan discharge should always be in the direction of the fan rotation.

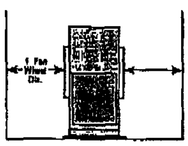
Fan performance is reduced when duct turns are made immediately off the fan discharge. To achieve cataloged fan performance there should be at least three equivalent duct diameters of straight ductwork between the fan discharge and any duct turns.



NON-DUCTED INSTALLATIONS

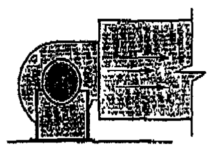
Non-Ducted Inlet Clearance

Installation of a fan with an open inlet too close to a wall or bulkhead will cause reduced fan performance. It is desirable to have one fan wheel diameter and a minimum of three-fourths of a wheel diameter between the fan inlet and the wall.



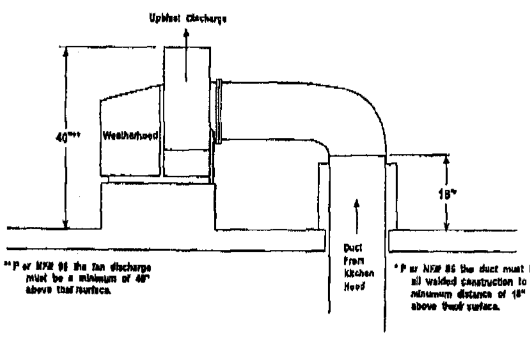
Free Discharge

Free or abrupt discharge into a plenum results in a reduction in fan performance. The effect of static regain in discharge is not realized.



CENTRIFUGAL - Outdoor Installation for UL 762 Listed Fans for Restaurant Exhaust

The UL 762 listing for restaurant exhaust is available on BISW fan sizes 7-73, Arr. 1 and 9 with belt guard and Arr. 10 with weatherhood. UL 762 fans are listed for a maximum operating temperature of 375°F and include a bolted access door and 1" drain connection. An outlet guard is strongly recommended when the fan discharge is accessible. An upblast discharge is recommended. The fan discharge must be a minimum of 40" above the roof line and the exhaust duct must be fully welded to a distance of 18" above the roof surface.



This drawing is for dimensional information only. See the latest edition of NFPA 96 Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations for detailed installation instructions, materials, duct connections and clearances.

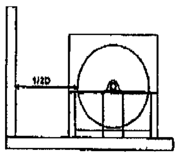
H 000420

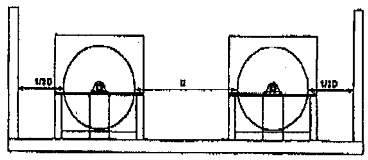
PLENUM AND PLUG FANS - INSTALLATIONS

UNHOUSED WHEELS

Adjacent Walls
The distance between the fan and walls or ceilings will effect the performance of the fan. The recommended distance between the fan wheel and any wall is a minimum of one - half wheel diameter. Multiple walls reduce the performance even more.

Side by Side
When two or more plenum fans are in parallel, there should be at least one fan diameter spacing between the wheels. Applications with less spacing will experience performance losses.

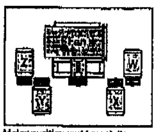




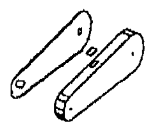
BELT GUARDS

Greenheck offers four types of customized belt guards dependent upon fan model, arrangement and motor position. The four types of belt guards are shown in illustrations to the right.

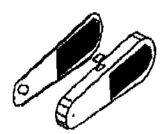
If the guard is not purchased from Greenheck, they must be supplied by the installer or owner.



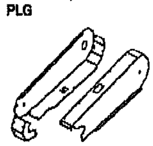
Motor position and fan rotation are determined from drive side



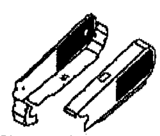
QEP & SW - Arr. 1, 3 (Mtr Pos. W / Z)
SW - Arr. 9, 10
PLG



DW - Arr. 3 (Mtr Pos. W / Z)

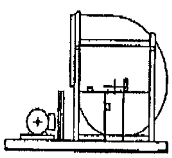


QEP & SW - Arr. 1, 3 (Mtr Pos. X / Y)

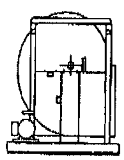


DW - Arr. 3 (Mtr Pos. X / Y)

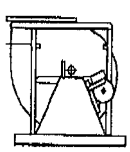
If the belt guard is not factory mounted or was not supplied by Greenheck, then it must be field mounted. **<u>Brackets and mounting hardware are the responsibility of the installer.</u>** The figures below illustrate suggested attachment points for belt guard mounting bracket locations. These locations vary with motor mounting position, arrangement, and fan type. The bearing supports and fan structure are used in most instances and when the motor is not mounted to the fan itself, a bracket should also be located near it. This information is intended as only a guide and actual field conditions may dictate another mounting location for the guard brackets. Refer to local codes for securing guarding.



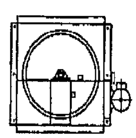
Mtr. Position: W/Z
Arr. - 1,3



Mtr. Position: X/Y
Arr. - 1,3



Mtr. Position: L/R
Arr. - 9



Mtr. Position: Side

Suggested Attachment Points

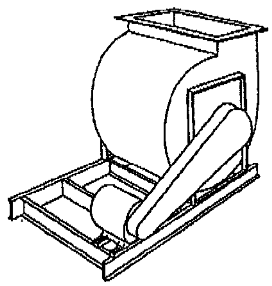
BASES

(FOUNDATION AND ISOLATION)

Critical to every fan installation is a strong, level foundation. A reinforced poured concrete pad with a structural steel base or inertia base provides an excellent foundation. Structural bases must be sturdy enough, with welded construction, to prevent flexing and vibration.

To eliminate vibration and noise from being transferred to the building, vibration isolators should be used. The fan is mounted directly on the isolation base and must be supported the entire length of the fan base angle (Refer to the installation manual for structural bases if the base was supplied by Greenheck). The isolators are installed between the isolation base and the foundation.

After the fan, isolation base, and isolators are installed, the entire assembly must be leveled. Position the level on the isolation base, not the fan shaft, for proper leveling. Additionally, the motor and fan shafts must be level and parallel relative to each other for proper alignment.



Typical Fan on Isolation Base

ROTATABLE HOUSINGS

It may be necessary to rotate the scroll of the fan to achieve a different discharge position than what was originally supplied. Centrifugal fans models BISW, AFSW, BIDW, and AFDW (sizes 7 - 30, arr. 1, 9, and 10, class I and II) and Industrial Process fans (sizes 5 - 19, standard and heavy duty) have the flexibility to be rotated in the field. This is accomplished by removing the housing bolts, rotating the housing to a new discharge position, and reinstalling the bolts.

RADIAL GAP, OVERLAP & WHEEL ALIGNMENT

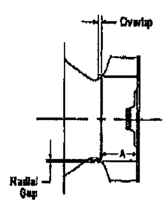
Efficient fan performance can be maintained by having the correct radial gap, overlap and wheel alignment. These items should be checked after the fan has been in operation for 24 hours and before start-up when the unit has been disassembled. Radial gap and overlap information applies to models: BISW, AFSW, BIDW, AFDW, QEP, and PLG.

Inlet Cone to Backplate Distance *not QEP* (inches)

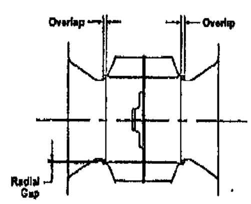
Unit Size	A dim. ± Tolerance	
7 - 10	3 5/8	± 1/8
12	4	± 1/8
13	4 7/16	± 1/8
15	5	± 1/8
16	5 7/16	± 1/8
18	6 3/8	± 1/8
20	7	± 3/16
22	7 13/16	± 3/16
24	8 5/8	± 1/4
27	9 7/16	± 1/4
30	10 9/16	± 3/8
33	11 7/16	± 3/8
36	12 3/4	± 3/8
40	14 3/16	± 3/8
44	15 9/16	± 3/8
49	17 1/8	± 1/2
54	18 13/16	± 1/2
60	20 15/16	± 1/2
66	22 7/8	± 1/2
73	25 1/2	± 1/2

QEP Inlet Cone to Backplate Distance (inches)

Unit Size	A dim. ± Tolerance	
12	3 1/2	± 1/8
15	5 3/8	± 1/8
16	5 7/8	± 1/8
18	6 1/2	± 1/8
20	7	± 1/8
22	7 7/8	± 1/8
24	8 5/8	± 1/8
27	9 1/2	± 1/8
30	10 5/8	± 1/8
33	11 3/4	± 1/8
36	13	± 1/8
40	14 1/4	± 1/8
44	15 3/4	± 1/8
49	17 3/8	± 1/8
54	19 1/4	± 1/8
60	21 1/4	± 1/8
66	23 3/8	± 1/8
73	25 7/8	± 1/8



BISW, AFSW, QEP, PLG



BIDW, AFDW

RADIAL GAP

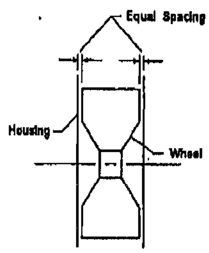
Radial gap is adjusted by loosening the inlet cone/ring bolts and centering the cone/ring on the wheel. If additional adjustment is required to maintain a constant radial gap, loosening the bearing bolts and centering wheel is acceptable as a secondary option.

OVERLAP

Overlap is adjusted by loosening the wheel hub from the shaft and moving the wheel to the desired position along the shaft. The Inlet Cone to Backplate Distance chart lists the distance between the wheel and the inlet cone spacing for non-double width fans. Overlap on double width fans is set by having equal spacing on each side of the wheel.

H 000422

WHEEL ALIGNMENT



IPA, IPO, IPW

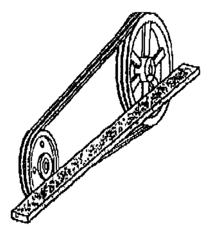
Correct wheel alignment for industrial process fans, models IPA, IPO, and IPW is achieved by centering the wheel in the housing.

V BELT DRIVES

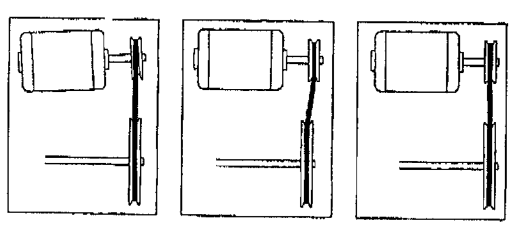
The V-belt drive components, when supplied by Greenheck Fan Corporation, have been carefully selected for this unit's specific operating condition. Caution: changing V-belt drive components could result in unsafe operating conditions which may cause personal injury or failure of the following components: 1. Fan Shaft, 2. Fan Wheel, 3. Bearings, 4. V-belt, 5. Motor.

V BELT DRIVE INSTALLATION

1. Remove the protective coating from the end of the fan shaft and assure that it is free of nicks and burrs.
2. Check fan and motor shafts for parallel and angular alignment.
3. Slide sheaves on shafts - do not drive sheaves on as this may result in bearing damage.
4. Align fan and motor sheaves with a straight-edge or string and tighten.
5. Place belts over sheaves. Do not pry or force belts, as this could result in damage to the cords in the belts.
6. Adjust the tension until the belts appear snug. Run the unit for a few minutes (see section on unit start-up) and allow the belts to "Set" properly.
7. With the fan off, adjust the belt tension by moving the motor base. (See belt tensioning procedures in the maintenance section of this manual). When in operation, the tight side of the belts should be in a straight line from sheave to sheave with a slight bow on the slack side.



Aligning Sheaves with a Straight Edge



Improper Sheave Alignment

Proper Sheave Alignment

H 000423

UNIT START UP

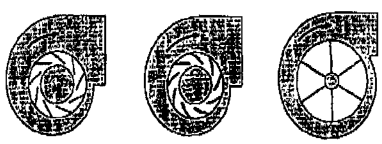
1. Disconnect and lock-out all power switches to fan. See warning below.
2. Check all fasteners, set screws and locking collars on the fan, bearings, drive, motor base and accessories for tightness.
3. Rotate the fan wheel by hand and assure no parts are rubbing.
4. Check for bearing alignment and lubrication.
5. Check the V-belt drive for proper alignment and tension.
6. Check the all guarding (if supplied) for being securely attached and not interfering with rotating parts.
7. Check operation of variable inlet vanes or discharge dampers (if supplied) for freedom of movement.
8. Check all electrical connections for proper attachment.
9. Check housing and ductwork, if accessible, for obstructions and foreign material that may damage the fan wheel.

WARNING
Disconnect and secure to the "Off" position all electrical power to the fan prior to inspection or servicing. Failure to comply with this safety precaution could result in serious injury or death.

ADDITIONAL STEPS FOR INITIAL START-UP

1. Check for proper wheel rotation by momentarily energizing the fan. Rotation is always determined by viewing the wheel from the drive side and should correspond to the rotation decal affixed to the unit. One of the most frequently encountered problems with Centrifugal Fans is motors which are wired to run in the wrong direction. This is especially true with 3-phase installations where the motor will run in either direction, depending on how it has been wired. To reverse rotation of a 3-phase motor, interchange any two of the three electrical leads. Single phase motors can be reversed by changing internal connections as described on the motor label or wiring diagram.

CW ROTATION



Centrifugal Backward Inclined — Centrifugal Airfoil — Industrial Process Radial Blade

Always viewed from the drive side.

2. If the fan has inlet vanes, they should be partially closed to reduce power requirements. This is especially important if the fan is designed for a high temperature application and is being started at room temperature.
3. Fans with multi-speed motors should be checked on low speed during initial start-up.
4. Check for unusual noise, vibration or overheating of bearings. Refer to the "Troubleshooting" section of this manual if a problem develops.
5. Grease may be forced out of the bearing seals during initial start-up. This is a normal self-purging feature of this type of bearing.

H 000424

VIBRATION

Excessive vibration is the most frequent problem experienced during initial start-up. Left unchecked, excessive vibration can cause a multitude of problems, including structural and/or component failure. The most common sources of vibration are listed below.

1. Wheel Unbalance
2. Drive Pulley Misalignment
3. Incorrect Belt Tension
4. Bearing Misalignment
5. Mechanical Looseness
6. Faulty Belts
7. Drive Component Unbalance
8. Poor Inlet/Outlet Conditions
9. Foundation Stiffness

Many of these conditions can be discovered by careful observation. Refer to the trouble-shooting section of this manual for corrective actions. If observation cannot locate the source of vibration, a qualified technician using vibration analysis equipment should be consulted. If the problem is wheel unbalance, in-place balancing can be done providing there is access to the fan wheel. Any correction weights added to the wheel should be welded to either the wheel back (single plane balance) or to the wheel back and wheel cone (two-plane balance).

Greenheck performs a vibration test on all centrifugal fans before shipping. Three vibration readings are taken on each bearing in the horizontal, vertical, and axial directions. The allowable maximum vibration is 0.15 in/sec. peak velocity filter-in at the fan rpm per AMCA standard 204. These vibration signatures are a permanent record of how the fan left the factory and are available upon request.

Generally, fan vibration and noise is transmitted to other parts of the building by the ductwork. To eliminate this undesirable effect, the use of heavy canvas connectors is recommended. If fireproof material is required, Flexweave 1000 - type FN-30 can be used.

ROUTINE MAINTENANCE

Once the unit has been put into operation, a routine maintenance schedule should be set up to accomplish the following:

1. Lubrication of bearings and motor.
2. Variable inlet vanes should be checked for freedom of operation and wear.
3. Wheel, housing, bolts and set screws on the entire fan should be checked for tightness.
4. Any dirt accumulation on the wheel or in the housing should be removed to prevent unbalance and possible damage.
5. Isolation bases should be checked for freedom of movement and the bolts for tightness. Springs should be checked for breaks and fatigue. Rubber isolators should be checked for deterioration.
6. Inspect fan impeller and housing looking for fatigue, corrosion, or wear.

When performing any service to the fan, disconnect the electrical supply and secure fan impeller.

CAUTION:
When operating conditions of the fan are to be changed (speed, pressure, temperature, etc.) consult Greenheck to determine if the unit can operate safely at the new conditions.

MOTORS

Motor maintenance is generally limited to cleaning and lubrication. Cleaning should be limited to exterior surfaces only. Removing dust and grease buildup on the motor housing assists proper motor cooling. Never wash-down motor with high pressure spray. Greasing of motors is only intended when fittings are provided. Many fractional motors are permanently lubricated for life and require no further lubrication. Motors supplied with grease fittings should be greased in accordance with the manufacturer's recommendations. When motor temperature does not exceed 104°F (40°C), the grease should be replaced after 2000 hours of running time.

BEARINGS

The bearings for Greenheck fans are carefully selected to match the maximum load and operating conditions of the specific class, arrangement, and fan size. The instructions provided in this manual and those provided by the bearing manufacturer, will minimize any bearing problems. Bearings are the most critical moving part of the fan, therefore special care is required when mounting them on the unit and maintaining them.

Refer to the following chart and the manufacturers instructions for grease types and intervals for various operating conditions. Never mix greases made with different bases. This will cause a breakdown of the grease and possible failure of the bearing.

Recommended Bearing Lubrication Schedule for Greenheck Fans

Relubrication Schedule in Months*

Fan RPM	Bearing Bore (inches) $\frac{1}{2}$ - 1	$1\frac{1}{8}$ - $1\frac{1}{2}$	$1\frac{5}{8}$ - $1\frac{7}{8}$	$1\frac{15}{16}$ - $2\frac{3}{16}$	$2\frac{7}{16}$ - 3	$3\frac{3}{16}$ - $3\frac{1}{2}$	$3\frac{15}{16}$ - $4\frac{1}{2}$	$4\frac{15}{16}$ - $5\frac{1}{2}$
To 250	6	6	6	6	6	5	4	3
500	6	6	6	5	4	3	3	2
750	6	5	4	3	3	2	2	1
1000	6	4	3	2	2	1	1	0.5
1250	5	3	2	1	1	0.5	0.5	0.25
1500	5	2	1	1	0.5	0.5	0.25	0.25
2000	5	1	1	0.5	0.25	0.25	0.25	0.25
2500	4	0.5	0.5	0.25	0.25	0.25		
3000	4	0.5	0.25	0.25	0.25			
4000	3	0.25	0.25	0.25	0.25			
5000	2	0.25	0.25	0.25				

* Suggested initial greasing interval is based on 12 hour per day operation and 150 degree F. maximum housing temperature. For continuous (24 hour) operation, decrease greasing interval by 50%.

- If possible relubricate with grease while in operation, without endangering personnel.
- For ball bearings (operating) relubricate until clean grease is seen purging at the seals. Be careful not to unseat the seal by over lubricating.
- For ball bearings (idle) add 1-2 shots of grease up to 2" bore sizes, and 4-5 shots of grease above 2" bore sizes with hand grease gun.
- For roller bearings relubricate with 4 shots of grease up to 2" bore size, 8 shots for 2"-5" bore size, and 16 shots above 5" bore size with hand grease gun.
- Adjust lubrication frequency based on condition of purged grease.
- A high quality lithium base grease conforming to NLGI Grade 2 consistency, such as those listed below, should be used.

MOBILUTH SHC 220	TEXACO MULTIFAK AFB2	SHELL ALVANIA #2
MOBILUTH AW2	TEXACO PREMIUM RB	EXXON UNIREX N2

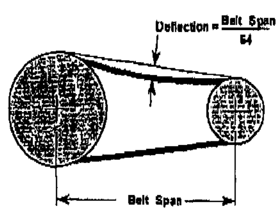
WARNING: Lubricate bearings prior to periods of extended shutdowns or storage and rotate shaft monthly to aid in preventing corrosion. If the fan is stored more than three months, the bearings should be purged with new grease prior to start-up.

V-BELT DRIVES

V-belt drives must be checked on a regular basis for wear, tension, alignment and dirt accumulation. Premature or frequent belt failures can be caused by improper belt tension, (either too loose or too tight) or misaligned sheaves. Abnormally high belt tension or drive misalignment will cause excessive bearing loads and may result in failure of the fan and/or motor bearings. Conversely, loose belts will cause squealing on start-up, excessive belt flutter, slippage, and overheated sheaves. Either excessively loose or tight belts may cause fan vibration.

When replacing V-belts on multiple groove drives all belts should be changed to provide uniform drive loading. Do not pry belts on or off the sheave. Loosen belt tension until belts can be removed by simply lifting the belts off the sheaves. After replacing belts, insure that slack in each belt is on the same side of the drive. Belt dressing should never be used.

Do not install new belts on worn sheaves. If the sheaves have grooves worn in them, they must be replaced before new belts are installed.



The proper tension for operating a V-belt drive is the lowest tension at which the belts will not slip at peak load conditions. For initial tensioning, the proper belt deflection half-way between sheave centers is 1/64" for each inch of belt span. For example, if the belt span is 64 inches, the belt deflection should be 1 inch using moderate thumb pressure at mid-point of the drive. Check belt tension two times during the first 24 hours of operation and periodically thereafter.

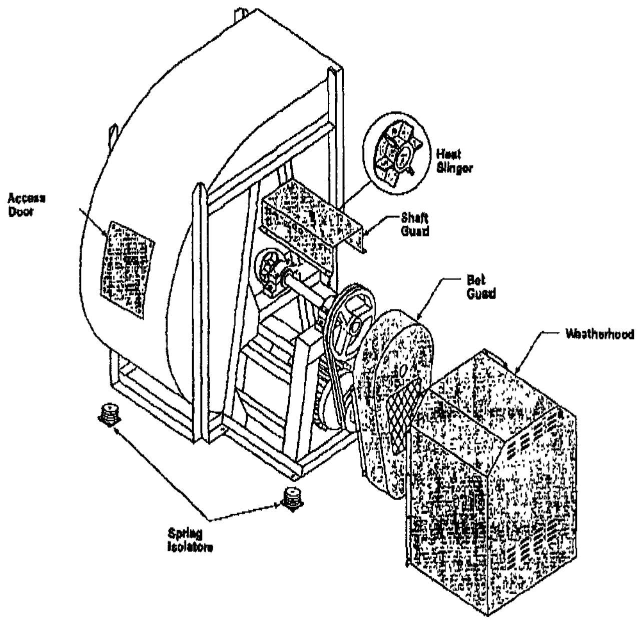
TROUBLESHOOTING

Problem	Cause	Corrective Action
Excessive Noise	Wheel Rubbing Inlet	Adjust wheel and/or inlet cone. Tighten wheel hub or bearing collars on shaft.
	V-Belt Drive	Tighten sheaves on motor/fan shaft. Adjust belt tension. Align sheaves properly (see page 7). Replace worn belts or sheaves.
	Bearings	Replace defective bearing(s). Lubricate bearings. Tighten collars and fasteners.
	Wheel Unbalance	Clean all dirt off wheel. Check wheel balance, rebalance in-place if necessary.
Low CFM	Fan	Check wheel for correct rotation. Increase fan speed.*
	Duct System	See page 3.
High CFM	Fan	Decrease fan speed.
	Duct system	Resize ductwork. Access door, filters, grills not installed.
Static Pressure Wrong	Duct system has more or less restriction than anticipated	Change obstructions in system. Use correction factor to adjust for temperature/altitude. Resize ductwork. Clean filters/coils. Change fan speed.*
High Horsepower	Fan	Check rotation of wheel. Reduce fan speed.
	Duct System	Resize ductwork. Check proper operation of face and bypass dampers. Check filters and access doors.
Fan Doesn't Operate	Electrical Supply	Check fuses/circuit breakers. Check for switches turned off or disconnected. Check for correct supply voltage.
	Drive	Check for broken belts. Tighten loose pulleys.
	Motor	Assure motor is correct horsepower and not tripping overload protector.
Overheated Bearing	Lubrication	Check for excessive or insufficient grease in the bearing.
	Mechanical	Replace damaged bearing. Relieve excessive belt tension. Align bearings . Check for bent shaft.
Excessive Vibration	Belts	Adjust tightness of belts. Replacement belts should be a matched set.
	System Unbalance	Check alignment of shaft, motor and pulleys. Adjustable pitch pulleys with motors over 15 hp motors are especially prone to unbalance. Check wheel balance, rebalance if necessary.

* Always check motor amps and compare to nameplate rating. Excessive fan speed may overload the motor and result in motor failure. Do not exceed the maximum cataloged rpm of of the fan.

NOTE: Always provide the unit model and serial numbers when requesting parts or service information.

CENTRIFUGAL / INDUSTRIAL PARTS DRAWING



WARRANTY

Greenheck warrants this equipment to be free from defects in material and workmanship for period of one year from the purchase date. This warranty limits our responsibility to repairing or replacing, to the original purchaser, any part or parts of said equipment found to be defective upon examination by representatives of Greenheck. Additionally, said part or parts will be returned to and received by the factory only after prior authorization, with transportation charges prepaid.

Greenheck shall not be obligated under this warranty, for payment of any delivery, removal or installation charges with regard to repair or replacement of any defective part or parts.

Motors are warranted by the motor manufacturer for a period of one year. Should motors furnished by Greenheck prove defective during this period, they should be returned to the nearest authorized motor service station.

GREENHECK
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PN 463687 Cent. Belt IOM FS
Rev. 1 October 2003

DPL SERIES - DELHI PLENUM FAN
INSTALLATION AND MAINTENANCE INSTRUCTIONS

MODELS: DPL-12, DPL-13, DPL-15, DPL-16, DPL-18, DPL-20, DPL-22, DPL-24, DPL-27, DPL-30, DPL-33, DPL-36

Read installation and operation instructions carefully before attempting to install, operate or service DELHI PLENUM FANS. Failure to comply with instructions could result in personal injury and/or property damage. Retain instructions for future reference.

UNPACKING

Once the packaging has been removed inspect the unit carefully. Check for loose, missing, or damaged parts. Rotate the wheel by hand to ensure the wheel spins freely. Tighten all set screws.

Maximum HP Ratings and Shaft Details

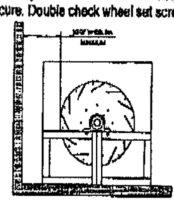
MODEL	DPL-12	DPL-13	DPL-15	DPL-16	DPL-18	DPL-20	DPL-22	DPL-24	DPL-27	DPL-30	DPL-33	DPL-36
SHAFT DIA	1	1	1	1-3/16	1-3/16	1-3/16	1-3/16	1-7/16	1-7/16	1-11/16	1-11/16	1-15/16
MAX RPM	3550	3200	2900	2600	2300	2150	1900	1750	1580	1420	1300	1180
MAX HP	5	5	5	7-1/2	7-1/2	10	10	15	15	20	25	30

GENERAL SAFETY INSTRUCTIONS

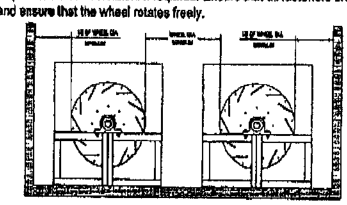
1. Always disconnect power source before working on or near a motor or its connected load. Lock the power disconnect in the off position and tag to prevent unauthorized application of power.
2. Follow all local and national electrical and safety codes.
3. Blower must be electrically grounded. This can be accomplished by using a separate ground wire connected to the bare metal of blower frame, or other suitable means.
4. Ensure that the power source conforms to the requirements of your equipment.
5. Do not put hands near or allow loose and hanging clothing to be near belts, pulleys, or blower wheel while the unit is running.

INSTALLATION

Mount blower on solid rigid flat base and secure with suitable fasteners through mounting holes provided in the cabinet frame assembly and motor frame assembly (optional). Use optional vibration isolators if required. Ensure that all fasteners are tight and secure. Double check wheel set screw for tightness and ensure that the wheel rotates freely.



ADJACENT PLENUM WALLS



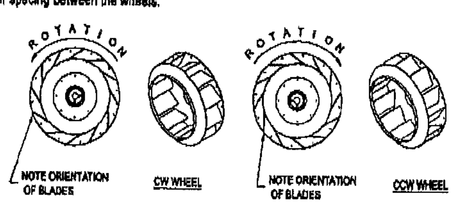
SIDE BY SIDE PLENUM FANS

The distance between the fan and walls or ceilings will effect the performance of the fan. The recommended distance between the fan wheel and any wall is a minimum of one - half wheel diameter. Multiple walls reduce the performance even more. When two or more plenums fans are in parallel, there should be at least one fan diameter spacing between the wheels.

Test the fan to ensure the rotation of the wheel is the same as indicated by the arrow marked Rotation.

Note: Wheel Orientation Nomenclature (CW/CCW) is based upon viewing rotation from the drive side.

The illustrated wheels are shown from inlet side.



DPL SERIES - DELHI PLENUM FAN
INSTALLATION AND MAINTENANCE INSTRUCTIONS
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BELT TENSION & PULLEY ALIGNMENT

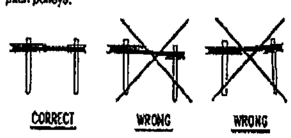
Proper belt tension and alignment is essential for quiet operation and bearing life. Follow illustrated recommendations on belt installation below.

RESILIENT BASE MOUNT MOTORS
With the belt grasped as shown a total deflection of 1" (1/2" on each side) should be easily attained. See figure 1.

Fig. 1

PULLEY ALIGNMENT
Align pulleys with a straight edge to conserve belt life and eliminate unnecessary noise.

NOTE: Pulley alignment may change when adjusting variable pitch pulleys.



Check tension before start-up, after every pulley adjustment and regularly thereafter.

RIGID BASE MOTORS - GOOD METHOD
Release the tension from the belt ensuring there is no slack. Measure the distance between shaft centres. Release the tension from the belt ensuring there is no slack. Measure the distance between shaft centres. Add 1% to the shaft centre distance and adjust the shaft centres until that value is obtained. Example: The untensioned shaft centres on a model DPL-22 fan measures 25-9/16" Tensioned centres = 25-9/16 x 1.01 = 25-13/16" (1/4" extension). See figure 2.

RIGID BASE MOTORS - BETTER METHOD
Using a tension gauge, apply 4 lbs of force to the centre of the belt and adjust the tension until a deflection of 1/64" for every inch of shaft centre is obtained. See Figure 3.

RIGID BASE MOTORS - PERFECT METHOD
Ideal belt tension is the lowest value under which belt slip will not occur at peak load conditions.

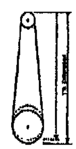
Fig. 2


Fig. 3


	MODEL	DPL-12	DPL-13	DPL-15	DPL-16	DPL-18	DPL-20	DPL-22	DPL-24	DPL-27	DPL-30	DPL-33	DPL-36
CENTER	48	15.19	16.19	17.50	18.31	19.75	21.25						
LINE	56/56H	15.69	16.69	17.94	18.81	20.25	21.75	23.94	25.69	27.75	29.75	32.06	34.81
DISTANCE	143T/145T	15.94	16.94	18.25	19.13	20.56	22.00	24.19	26.00	28.06	30.00	32.31	35.13
FOR	182T/184T	17.31	18.25	19.50	20.44	21.88	23.31	25.56	27.31	29.38	31.38	33.63	35.44
OPTIONAL	213T/215T				21.25	22.69	24.13	26.38	28.13	30.13	32.25	34.50	37.25
MOTOR	254T/256T							27.56	29.25	31.25	33.38	35.50	38.25
PLATFORM	284T/286T										34.13	36.31	39.00

ELECTRICAL

Connect motor in accordance with applicable codes. Provide properly sized motor overload protection to protect motor against electrical faults and system changes. Confirm proper motor rotation on start-up.

MAINTENANCE

Inspect periodically for mounting rigidity. Verify belt for wear and tension and adjust as required. Inspect wheel for any dust accumulation and clean as indicated.

LUBRICATION

Cast iron, pillow block, sealed type, bearings are used on all DPL PLENUM FANS. Operating temperature range is -30 to 230 deg. F. Re-lubrication is unnecessary under most operating conditions. If re-lubrication is required, lubricant should be compatible to Shell Alvania #2. (Lithium base - Grade 2)

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DPLOIPM

H 000430

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 205 979 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: 86107313.8

(22) Date of filing: 30.05.86

(51) Int. Cl.⁴: **E 21 F 1/00**

(30) Priority: 11.06.85 JP 125056/85

(43) Date of publication of application: 30.12.86 Bulletin 86/52

(84) Designated Contracting States: DE FR GB

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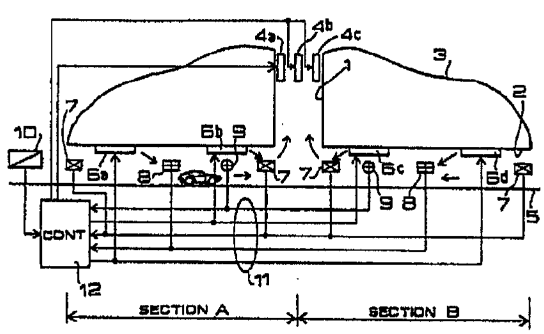
(54) Tunnel ventilating system.

(57) A tunnel ventilating system for ventilating a highway tunnel (2) comprises a plurality of jet fans (6a, b, c, d) for drawing fresh air through the opposite portals of the highway tunnel into the highway tunnel and for causing the fresh air to flow toward a ventilating shaft (1), a plurality of ventilating fans (4a, b, c) for discharging the air in the highway tunnel through the ventilating shaft, and a controller (12) capable of determining necessary rate of ventilation on the basis of measured data representing the degree of contamination of the air in the highway tunnel and other factors indicating the conditions of the interior of the highway tunnel. The jet fans and the ventilating fans are assigned to first and second subsystems. The jet fans and the ventilating fans of the first subsystem are operated under on-off control mode, while the jet fans and the ventilating fans of the second subsystem are operated under variable rate control mode. Thus, the highway tunnel is always ventilated at the necessary rate of ventilation.



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TUNNEL VENTILATING SYSTEM

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a ventilating system for the enclosed space of various buildings or structures and, more specifically, to a ventilating system for ventilating a tunnel. The ventilating system is of the type comprising a plurality of jet fans for causing the air introduced into a tunnel from outside to flow toward one or a plurality of ventilating ducts, a ventilating fan for discharging the air through the ventilating duct or ducts outside the tunnel, and a controller for controlling the jet fans and the ventilating fan according to the flow rate of air required for desired ventilation.

Description of the Prior Art

A tunnel has a structural feature that the length the length thereof is very large as compared with the area of the opposite ends thereof. Therefore, the tunnel requires an adequate ventilation to maintain an environment suitable for passage. For a highway tunnel, high-rate ventilation is essential to cause fresh air to circulate through and contaminated air containing the exhaust gas of automotive vehicles to be simultaneously withdrawn from the tunnel and to supply fresh air containing sufficient oxygen for the human bodies and the combustion in the engines of automotive vehicles.

Fig. 5 illustrates a known tunnel ventilating system for a highway tunnel. Such a tunnel ventilating system is disclosed in Japanese Laid-Open Patent Application Publication No. 52-28500. Referring to Fig. 5, a highway tunnel 2 constructed under the ground 3 and having a roadway 5 communicates with the outside by means of a substantially vertical ventilating shaft 1. A plurality of jet fans 6 draw fresh air through the opposite portals into the tunnel 2 and send the fresh air forcibly in the longitudinal direction toward the ventilating shaft 1. A ventilating fan 4 is disposed within the ventilating shaft 1 near the outlet of the same to discharge the air in the tunnel 2 forcibly outside the tunnel 2.

A controller 12 controls the jet fans 6 and the ventilating fan 4 on the basis of signals given thereto by a contamination detecting system for detecting the degree of contamination of the air within the tunnel 2 and a counter for counting the automotive vehicles that go into and come out of the tunnel 2. Typically, the contamination detecting system comprises haze transmissivity meters 7 (generally designated as "VI meters"), CO sensors 8 which detect the CO concentration of the atmosphere, and wind vane and anemometers 9. The controller 12 decides the general degree of air contamination in the tunnel on the basis of data acquired by those measuring instruments and calculates the quantity of fresh air necessary for maintaining the environment of the tunnel in a satisfactory condition.

An appropriate ventilating system among various ventilating systems is selected by taking the conditions of the tunnel, such as the length, cross-sectional area, gradient and traffic volume of the tunnel, into consideration. Supplying sufficient fresh air to maintain the quality of the air inside the tunnel above the lower limit of a desired level and discharging contaminated air outside the tunnel are essential regardless of the type of the selected tunnel ventilating system, however, from the economic point of view, excessive ventilation is undesirable.

In the above-mentioned prior art tunnel ventilating system, the number of working jet fans 6 is varied according to the calculated necessary rate of ventilation. That is, all the jet fans are operated when the necessary rate of ventilation is greater than a predetermined value, while the number of the working jet fans is reduced as the necessary rate of ventilation decreases. Such a mode of controlling the rate of ventilation through the variation of the number of the operating jet fans causes the rate of ventilation to be changed in steps, and hence the actual rate of ventilation always exceeds the corresponding necessary rate of ventilation between the steps of variation.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a ventilating system capable of ventilating the internal space of a building or a structure at the least necessary

rate of ventilation.

A ventilating system according to the present invention comprises a plurality of jet fans provided within a space to be ventilated to draw fresh air into the space, and a plurality of ventilating fans provided in a ventilating shaft for discharging the air in the space outside the space. The jet fans and the ventilating fans are respectively assigned to two subsystems, namely, a first subsystem and a second subsystem. The jet fan or fans of the first subsystem and the ventilating fan or fans of the first subsystem are subjected to the on-off control of a controller, while the jet fan or fans and the ventilating fan or fans of the second subsystem are subjected to the continuous control of the controller, in which the respective outputs of the jet fan or fans and the ventilating fan or fans of the second subsystem are varied continuously. The controller is capable of calculating the necessary rate of ventilation to establish a standard for controlling the first and second subsystems for desired ventilation, on the basis of data representing the degree of contamination of the air in the space detected by one or some of sensors disposed in the space to be ventilated.

The sensors for acquiring the data relating to the contamination of air are, by way of example, CO sensors, anemoscopes, anemometers, O_2 meters and hygrometers. One or more of those sensors are disposed at appropriate positions in the space to be ventilated. The sensors

send detection signals to the controller. In case that the space to be ventilated is a highway tunnel, it is desirable to provide a counter for counting the number of automotive vehicles that pass the highway tunnel. The count of automotive vehicles that passed in a unit time counted by the counter is effective for the estimation of the necessary rate of ventilation of the highway tunnel.

The controller decides the respective numbers of the working jet fans and the working ventilating fans among those of the first subsystem on the basis of the calculated necessary rate of ventilation. The mode of control of the jet fans and the ventilating fans of the first subsystem is on-off control. Accordingly, the selected jet fans and ventilating fans are operated at the respective maximum capacities. The number of the jet fans and the ventilating fans of the first subsystem selected for operation by the controller is less than that of the jet fans and the ventilating fans necessary for meeting the desired rate of ventilation. The deficiency in the rate of ventilation is compensated by the operation of the jet fans and the ventilating fans of the second subsystem at the respective rates corresponding to the deficiency. Accordingly, the actual rate of ventilation always coincides with the necessary rate of ventilation and thereby the waste of energy attributable to excessive ventilation can be effectively avoided.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic illustration of a tunnel ventilating system according to the present invention installed in a highway tunnel;

Figure 2 is a block diagram showing the constitution of a controller employed in the tunnel ventilating system of Fig. 1;

Figure 3 is a graph showing the relation between the number of working jet fans and wind pressure;

Figure 4 is a graph showing the relation between the number of working ventilating fans and the rate of discharge; and

Figure 5 is a schematic illustration of a conventional tunnel ventilating system installed in a highway tunnel.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 illustrates a tunnel ventilating system according to the present invention as applied to a highway tunnel 2 constructed through the ground 3 and having a roadway 5. The tunnel 2 is connected in the central portion thereof with respect to the length thereof to a vertical ventilating shaft 1. Fresh air is drawn through the opposite portals into the tunnel 2 and the air in the tunnel is discharged outside through the ventilating shaft 1 for desired ventilation of the tunnel. Although the ventilating system illustrated in Fig. 1 is so constructed that the fresh air is introduced into the inside of the tunnel through the portals at both ends, the present invention is applicable to another

form of ventilation wherein the fresh air is introduced through one of the portals and then discharged outside through a duct and at the same time the fresh air is introduced through another duct into the tunnel and exhausted through the other portal.

For simplification, four jet fans 6a, 6b, 6c and 6d disposed in the tunnel 2 at predetermined intervals and three ventilating fans 4a, 4b and 4c disposed within the ventilating shaft 1 are shown in Fig. 1. The ventilation of the tunnel 2 in the above-mentioned mode is carried out by the agency of these jet fans and ventilating fans. As will be described in detail later, the two jet fans 6a and 6d and the two jet fans 6b and 6c are assigned to two separate subsystems, respectively. Similarly, the ventilating fan 4a and the ventilating fans 4b and 4c are assigned to two separate subsystems, respectively.

A controller 12 controls the subsystems individually for the appropriate operation of the jet fans and the ventilating fans according to a necessary rate of ventilation. Such a necessary rate of ventilation is obtained through the known operation of VI value, CO value, wind speed, wind direction and the count of automotive vehicles passed through the tunnel which are detected by sensors 7, 8, 9 and 10 appropriately disposed in the tunnel, by the controller 12.

Fig. 2 shows the constitution of the controller 12 in detail. A measured data processing unit 13 receives

measured values measured by the VI meter 7 and the CO sensor 8, and then operates the measured data to determine the degree of air contamination in the tunnel. An arithmetic unit 14, similarly to the measured data processing unit 13, executes operation to determine the pressure condition of the interior of the tunnel on the basis of measured data provided by the wind vane and anemometer 9 and the vehicle counter 10. The outputs of the measured data processing unit 13 and the arithmetic unit 14 are given to a control signal generating unit 15 to produce control signals for the individual control of the subsystems comprising the jet fans and the ventilating fans.

Fig. 3 is a graph typically showing the relation between the number of working jet fans and wind pressure in the tunnel resulting from the operation of those jet fans in a section A between one of the portals of the tunnel and the ventilating shaft 1. In Fig. 3, P1 and P2 are airflow pressures produced by one jet fan and by two jet fans, respectively. When necessary rate of ventilation is comparatively small and, hence, the required wind pressure in the longitudinal direction of the tunnel is less than P1, only one jet fan is operated at a rate corresponding to the required wind pressure. In this state, the wind pressure varies along an inclined line VP1. When the required wind pressure is greater than P1, two jet fans are operated; one of them at its full capacity and the other under variable capacity control. In this state,

the wind pressure varies along a line VP2. If one of the two jet fans or both of the jet fans are operated continuously at full capacity under a condition other than a condition in which the required wind pressure coincides exactly with the wind pressure P1 or P2, respectively, the actual wind pressure in the tunnel exceeds the required wind pressure and the excessive wind pressure causes wasteful energy consumption. According to the present invention, it is possible to make the actual wind pressure always follow up the required wind pressure. In the highway tunnel, even if the operating condition of the jet fans is fixed, the wind pressure varies due to piston effect produced by automotive vehicles that pass through the highway tunnel at high speed. Since the tunnel ventilating system of the present invention is capable of dealing with the variation of the wind pressure due to such a cause on the basis of measured values of wind direction and wind speed, the highway tunnel is ventilated stably at all times, which is the same with a section B.

The ventilating fans 4a, 4b and 4c also are controlled in the same manner. Fig. 4 shows the relation of discharge or exhaust rate to the number of the working ventilating fans. When a required sicharge rate corresponding to a necessary rate of ventilation is below the maximum discharge rate Q1 of one ventilating fan, only the ventilating fan 4a is operated at a discharge rate corresponding to the required discharge rate. When the required discharge rate

is greater than the maximum discharge rate Q1, one or both of the ventilating fans 4b and 4c are additionally operated at the maximum discharge rate to obtain a control characteristic represented by a line VQ.

As is apparent from what has been described hereinbefore, the tunnel ventilating system according to the present invention is capable of exactly meeting the necessary rate of ventilation and is also capable of dealing with the variation of the wind pressure attributable to the traffic of automotive vehicles through the tunnel, and hence the tunnel ventilating system according to the present invention is most advantageously applicable to railroad tunnels, subway tunnels and the like in addition to highway tunnels. It is apparent that the tunnel ventilating system according to the present invention is applicable also to all the spaces of buildings and structures that require ventilation.

WHAT IS CLAIMED IS:

1. A ventilating system for ventilating a space formed within a building or a structure, and connected to the outside at least at one open end thereof, by discharging the air in the space through a ventilating shaft connected to the space, said ventilating system being of the type having a plurality of jet fans disposed within the space to draw fresh air into the space through the open end of the space and to cause the fresh air to flow within the space toward said shaft, a plurality of ventilating fans disposed within said ventilating shaft to discharge the air in the space outside the space through said ventilating shaft, and a controller for controlling said jet fans and said ventilating fans according to the necessary rate of ventilation of the space, the improvement comprising:

said jet fans and said ventilating fans are assigned to a first subsystem and a second subsystem;

said first and second subsystems are controlled individually by the controller;

said jet fans and said ventilating fans of said first subsystem are operated under on-off control mode; and

said jet fans and said ventilating fans of said second subsystem are operated under variable rate control mode so that the rate of ventilation of said second subsystem corresponds to the difference between the necessary rate of ventilation and the rate of ventilation of said first subsystem.

2. A ventilating system claimed in Claim 1, wherein haze transmissivity meters, CO sensors and wind vane and anemometers are provided in said space to acquire data for determining the necessary rate of ventilation.

3. A ventilating system claimed in Claim 2, wherein the structure defining said space is a highway tunnel, and a counter for counting the number of automotive vehicles that passes through the highway tunnel is provided.

4. A ventilating system claimed in Claim 3, wherein said controller comprises a measured data processing unit which processes signals given thereto by said haze transmissivity meters and said CO sensors to provide a signal representing the degree of air contamination, an arithmetic unit which operates signals given thereto by said wind vane and anemometers and said counters to provide a signal representing the pressure condition of said highway tunnel, and a control signal generating unit which determines the necessary rate of ventilation on the basis of the output signals of said measured data processing unit and said arithmetic unit and gives separate control signals corresponding to the necessary rate of ventilation to said first and second subsystems, respectively.

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FIG. 1

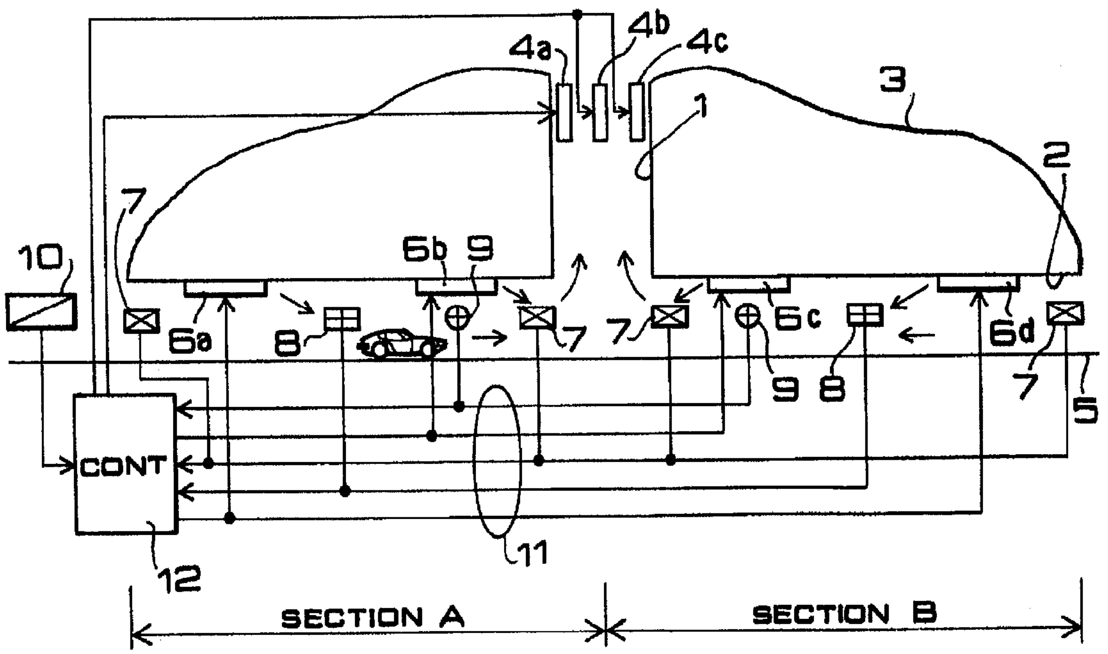
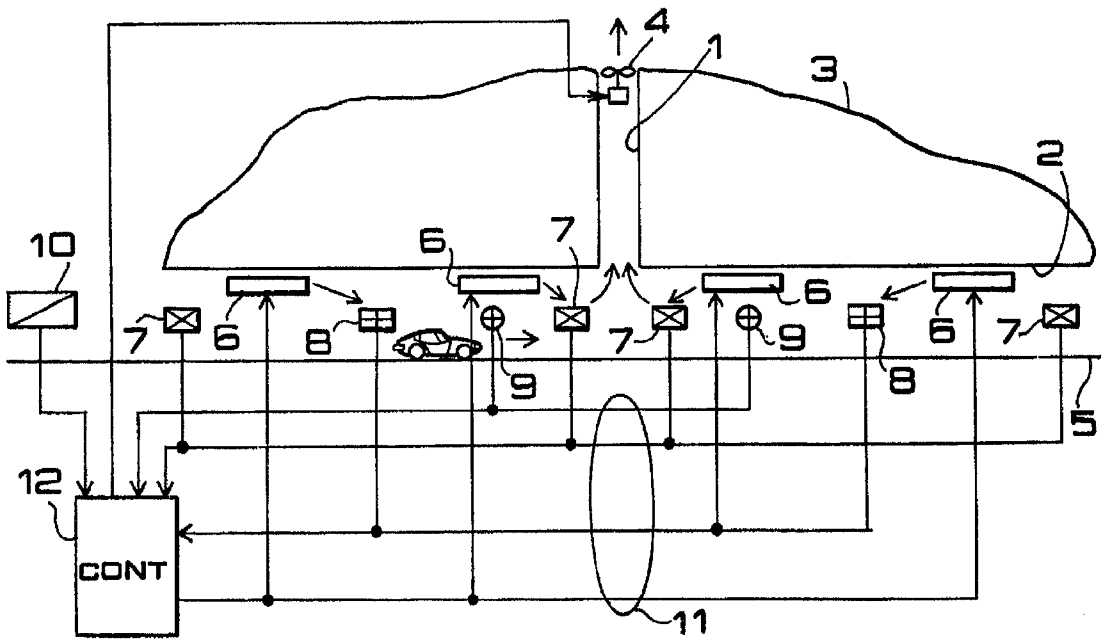


FIG. 5



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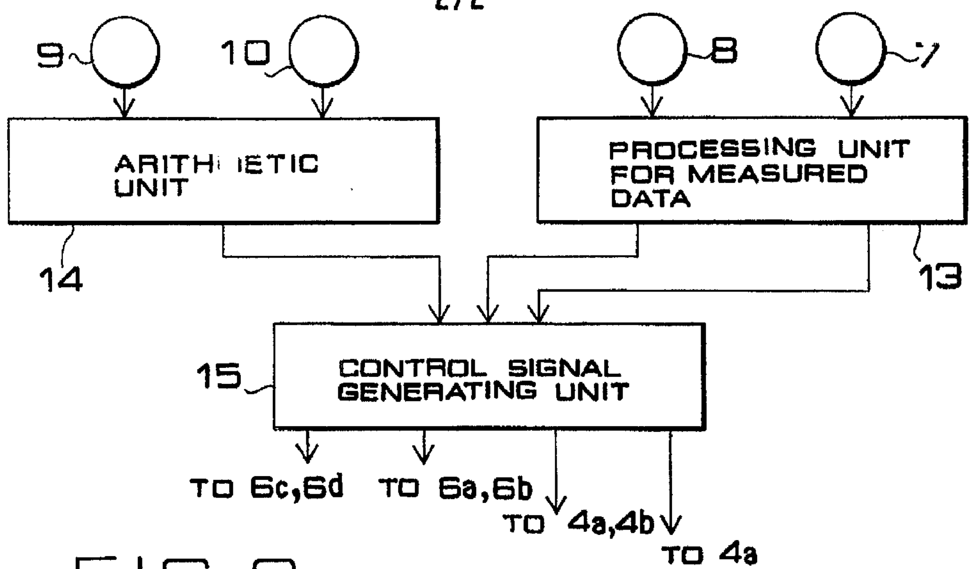


FIG. 2

FIG. 3

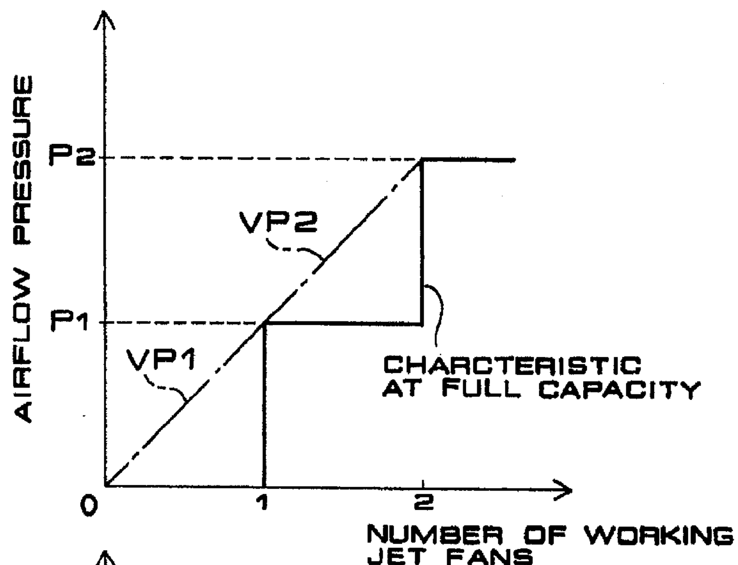
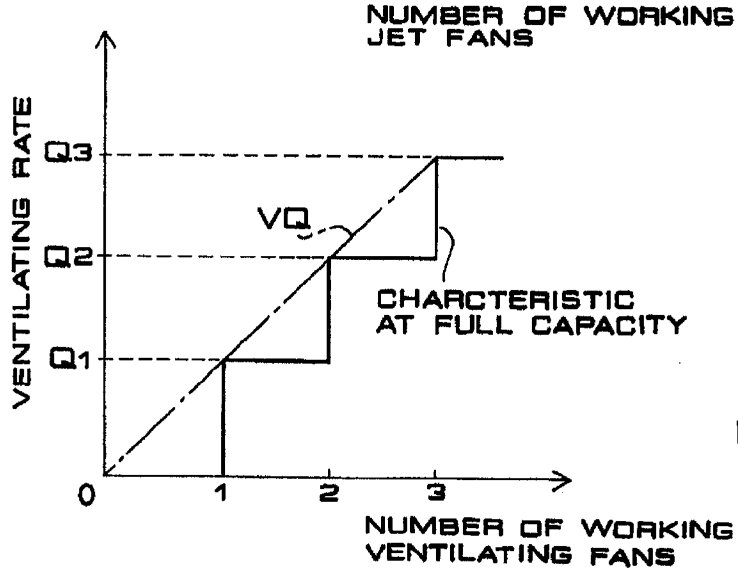


FIG. 4



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EUROPEAN SEARCH REPORT

0205979
Application number

EP 86 10 7313

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	DE-A-3 117 147 (DAIMLER-BENZ) * Abstract; figure 1 * ---	1,3,4	E 21 F 1/00
A	DE-A-2 005 424 (FÖLDIAK) ---		
A	FR-A-2 358 542 (SOFRAIR) -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.4)

E 21 F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16-09-1986	RAMPELMANN J.

CATEGORY OF CITED DOCUMENTS

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